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A COMPARISON OF THE DEVELOPMENTAL STAGES PROPOSED BY L. S. VYGOTSKY AND J. PIAGET

by

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Affectionately dedicated to

Bruce Roger Martin

ABSTRACT

The present study was designed to explore the relationship between the theoretical models of cognitive development proposed by J. Piaget and L. S. Vygotsky. Each theory was briefly described, and the rationale for comparison discussed in detail.

The subjects selected for this investigation were 104 children, aged 4 to 16 years. All were in the average range of intelligence, were in the usual school grade for their age, and had no history of neurological or emotional problems. Four males and four females at each successive age were tested. Vygotsky's developmental stages are based on performance on his "Blocks Test", but it was necessary to select Piagetian problems representative of his major quantity, weight and area stage levels. Conservation of substance, continuous quantity, discontinuous were chosen to discriminate between the pre-operational and concrete operational stages; while conservation of volume and density served to distinguish between the concrete stage and the period of formal operations. A brief verbal question involving formal reasoning was also included.

Subject responses were scored both qualitatively in terms of the described developmental model of each theorist, and quantitatively in terms of scoring systems devised by

other researchers.

On the basis of obtained results, it was concluded that both Piaget's and Vygotsky's models of cognitive development are truly representative of children's thought processes at all levels of sophistication. As well, the two theoretical models were found to be very closely related.

The Vygotsky Blocks emerged as an appropriate instrument for the assessment of concept formation in children. Performance on the blocks suggested that Vygotsky's first major phase occurs prior to age 4, with the second phase dominating until about 13 years, when the final phase takes over. The individual scoring variables used on the Blocks reflected specific aspects of test performance, but did not relate too closely to Vygotsky's stages. They did however, provide quantitative norms for the various age levels.

All aspects of Piaget's theory were also well supported, with the exception of the level of difficulty of the tasks. Conservation of weight was attained two years earlier than expected, and conservation of area proved to be much more easily solved than had been anticipated. Piaget's preferred explanation criteria proved to be a slightly better estimation of conservation, but there was surprisingly little difference between these scores and those based on initial judgements alone.

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Chapter I

Introduction

The Problem in Perspective

Theories of child development have abounded since time immemorial, proposed by men of varied academic backgrounds, differing philosophical orientations, and supported by varied amounts of empirical research. The very *raison d'etre* of these theories is the hypothesis that the normal child will develop according to a predictable pattern, given fairly consistent environmental conditions; some theories even go so far as to consider human development to be relatively constant, independent of environmental specifics. Thus it would be expected that developmental theories would contain many similar elements, particularly concerning the nature of child behavior and thought to be expected at a given point in evolution to adulthood. Yet writers in the area of developmental psychology have made little attempt to integrate current knowledge into a consistent picture, preferring to concentrate on points of dissention between various theories. Although there is no question that more research is needed into the nature of child development, it has also been frequently noted that information gathered to date has neither been fully exploited nor utilized to best

advantage. Thus a fruitful direction for current investigations would appear to be a thorough analysis of available developmental knowledge, for purposes of distilling out common elements independent of the particular philosophical perspective of the theorist. This, of course, is a monumental task. The present investigation, confined as it is to the area of cognitive development, and concerned with two major psychological theorists, represents a small step towards this goal. The theories selected for investigation were those of Jean Piaget and Lev Semenovich Vygotsky.

The most extensive work in the area of cognitive development has been carried out by Jean Piaget, a noted Swiss psychologist who has devoted the greater part of a lengthy life span to the investigation of the nature of child thought. Probably the most astute observer of child behavior in the world today, Piaget has catalogued the responses of hundreds of children, and from his findings formulated hypotheses concerning all areas of growth - including perception, speech, social and moral skills, as well as the learning of spatial, numerical and temporal concepts. Piaget has combined these specific observations into an overall theory of human mental development comprised of stages or levels of cognitive sophistication through which all children must pass en route to adult reasoning ability. These levels are loosely related to age criteria,

but it is order of succession rather than age of appearance which is the crucial variable. Piaget's research methods, his interpretation of findings, and his manner of reporting have been soundly and repeatedly criticized, particularly by American psychologists who prefer closely controlled empirical studies to the more observational European approach. In spite of (or perhaps because of) the storm of controversy aroused by his work, the significance of Piaget's contribution to developmental psychology has never been questioned. He has been described as "the century's most prolific writer and thecrist on the development of the child" (Baldwin, 1968, p.171), and as "bestriding the field of contemporary ontogenetic studies like a colossus" (Wallace, 1967, p. 53).

Less well known in the western world is the work of Lev Semenovich Vygotsky (1896-1934), a Soviet psychological theorist who engaged in the investigation of cognitive function during the last ten years of his life. Vygotsky's primary interest was the nature and development of the higher mental functions such as verbal thought, voluntary control, logical memory, and creative imagination, "which comprise the specific equipment of man as a social being" (Zaporohetz, 1967, p. 19). He studied the manner of thinking of children of all ages, as well as that of schizophrenic and neurologically impaired adults in the hope of specifying the differences between what Vygotsky

describes as "primitive" and "mature" reasoning capacities. Like Piaget, Vygotsky also proposed a series of stages of cognitive development based on his research findings regarding children. These, too, are roughly age related, but again it is the order of appearance which is of central concern. Although Vygotsky's general research methods are largely known, specific information concerning his actual studies has never been translated into English. Fortunately his primary research instrument, commonly referred to as the "Vygotsky Block Test", is available through the efforts of Eugenia Hanfmann and Jacob Kasanin, the American psychologists who first introduced his work to the western world. It is possible that Vygotsky used other methods of investigation as well; however, these are not known to us at present. The size and composition of his samples remains a mystery; thus, it is impossible to determine whether his findings can truly be considered representative of children in general. Later research generally supports his theories, but further evidence is needed. Notwithstanding this unfortunate lack of research data, Vygotsky's work represents an innovative and ingenious approach to human thought. In the words of Bruner (1966), Vygotsky's theory of intellectual development is "highly original," "closely reasoned," and "powerful."

Piaget and Vygotsky were contemporaries, investigating similar problems in separate areas of the world. Vygotsky

was familiar with Piaget's first two books (The Language and Thought of the Child, 1923, and Reasoning in the Child, 1924), but Piaget had no access to a detailed account of Vygotsky's theory until 1962, when the Russian's last book, Thought and Language, was translated into English. Vygotsky admired his colleague's work sufficiently enough to arrange for its translation into Russian, thus introducing it to other Soviet psychologists. Vygotsky disagreed with a good many early Piagetian ideas, but there is no doubt that Piaget's theory had a considerable influence on Vygotsky's work. As Piaget's views evolved over the years, the two theories progressively gained similarity. After reading Vygotsky's book (which devotes a chapter to Piaget's theory) Piaget published a paper replying to his colleague's comments in the light of later findings. This document reveals many new points of agreement (Piaget, 1962).

Purpose of Present Study

The purpose of this investigation was to compare the cognitive developmental theories of Vygotsky and Piaget. This was to be accomplished by ascertaining the cognitive level of a given child according to each system, and then correlating the results over a representative sample of children. The primary object was to discover whether it was possible to predict the corresponding Vygotsky stage from knowledge of Piagetian developmental level. As the subject sample was relatively large (N=104) and encompassed thirteen

age levels (from four years to sixteen), obtained results also provided insights into the validity of the stage concepts of each theoretical model, and the ages encompassed by same. Several scoring systems were employed for purposes of evaluation and comparison of their effectiveness.

Two independent raters also scored parts of the data, to guard against systematic examiner bias. Finally, present results were compared with those of other investigators to ascertain if any significant differences existed.

Chapter II

Review of Relevant Theory and Research

Theoretical Specifics Relevant to the Present Study

The theories of Piaget and Vygotsky were selected for study and comparison for a number of reasons in addition to the aforementioned similarities. For both theorists, but especially in the case of Vygotsky, more empirical evidence is needed regarding the validity of their proposed progressive developmental stages. Rationale for comparison of their theories rests primarily on the similarity of their overall orientation towards research, and their philosophies concerning the nature of human intellect. Both vehemently rejected the popular behaviorist philosophy which reduced man's psychological processes to a schema of conditioned reflexes, as they felt that human mental activity, particularly at the higher developmental levels, was far too complex to conform to such a simplistic model. Both theorists also felt strongly that human development involved much more than mere imitation of observed behavior. In the words of Vygotsky, "every external development is the result of an internal genetic law" (Elkonin, 1967). The goal of behaviorist research was to produce change in the responses

of their subjects; the goal of Piaget's and Vygotsky's investigations was simply observation of typical existing response patterns. The primary emphasis of the behaviorists was experimental design, rather than analysis of subject solutions, which played the major role in cognitive work. As such Piaget's and Vygotsky's research was "clinical" in nature, concerned more with why a subject produced a given response than with the superficial accuracy of his answer. To this end they would freely alter their manner of inquiry from subject to subject if they felt more information could be gained, a practice abhorred by more empirical colleagues.

The investigations of both men began by analyzing actual conditions of the child's reality. Their research method involved devising problems requiring certain lines of logical reasoning for their solution, which were then presented to children of various ages. The problems revealed levels of thinking regardless of whether a complete solution was found, and were relatively independent of educational experience and specific cultural activity. The purpose of these experiments was to provide situations which permitted observation of emerging thought processes in addition to completely developed functions, thus yielding qualitative rather than quantitative data. Vygotsky's research has been described by Elkonin (1967) as "abstract experimental models rather than empirical studies." The same is true of Piaget's work.

In his 1962 paper, Piaget writes

> "the main problem raised by Vygotsky is basically that of the adaptive and functional nature of the child and of every human being. On this point I certainly agree with him in the main" (1962a, p. 2).

Thus, their overall views of man correspond closely. These theorists both regard the development of individual cognitive processes in the larger context of overall human biological and social evolution. Intellect is thus first and foremost an adaptive function fostered by social experience. Both consider the latter to be particularly crucial to human development, as man is the only animal capable of communicating a lifetime of learning experience to another member of the species, since he alone is capable of symbolically representing reality via speech or sign. Thus, Piaget and Vygotsky sharply differentiate between the higher and lower mental functions on the basis of abstract conceptualization, and both consider the most sophisticated developmental levels of primary theoretical importance. As would be expected, the development of language and its relation to thought is of considerable concern to both investigators. Their views diverge somewhat in this area; however, the question of language development per se is not explored in the present study.

Piaget's theory of cognitive development has been described as "a progressive structurization, whereby actions and intellectual operations become organized into coherent systems" (Inhelder, 1966, p. 160), which applies aptly to

Vygotsky's outline as well. Each divides the route to mature thought into "units" (variously labelled periods, phases, stages, etc.), but more important, their views on the nature and function of these units are similar. Both consider the order of attainment invariable, but recognize that individual children reach a given level at different ages. Thus, rate of development may vary, but not overall pattern. A given stage represents the highest level of conceptualization of which a child is capable at that time, but he will not consistently operate at maximum efficiency so may be expected to use more primitive thought structures as well, depending on the nature of the problem. Piaget assigns approximate age levels to his stages representative of average age of attainment of various functions. Vygotsky probably did so as well, but there is no available record of his age parameters. It is suspected that Vygotsky worked primarily with school age children, as he was employed in an educationally-oriented institution. Therefore it is probable that Piaget's earliest period, the sensory-motor, has no equivalent in the Vygotsky system. Thus this first Piagetian period will not be considered in the present investigation.

M. Veer, (1967) in her discussion of the similarity between the theories of Piaget and A. V. Zaporozhets (a Soviet psychologist and student of Vygotsky) credits Vygotsky with being the "main link" between Piaget and

Soviet developmental theorists. She states "a whole gammut of Continental-European philosophies linked Piaget and Vygotsky" (p. 180). Veer notes that both Vygotsky and Piaget view mental development as a "snowballing" of past experience on present concerns; superimposed with Gestaltian structured wholes. Many of the "countless similarities" between Zaporozhets and Piaget cited by Veer apply equally well to the ideas of Vygotsky and Piaget. For example, both regard the study of cognitive processes as the best means for discovering the nature of child development; both have some biological bias re adaptation to situations; and both study mental processes by letting the child manipulate simple objects. Further, both are developmental psychologists in the same meaning of the term: they study the child's development and each of his single mental processes step by step, discover intriguingly different stages and see the child developing in interaction with the objective and human environment (p. 179). Veer also mentions several differences between the Soviet theorists and Piaget, but does not consider them cardinal. She concludes that "Essentially the psychological system which Zaporozhets represents is the same as Piaget's"(p. 188). Vygotsky, of course, is also a part of the same system.

All developmental psychologists are aware of the interaction of cognitive and emotional variables; so, just as there were intellectual reasons for selecting the work of

Piaget and Vygotsky for study, there were "emotional" considerations as well. These men could be labelled "humanistic" developmental psychologists, as both investigate and appreciate the child primarily for what he is, not for what he can be manipulated to become. Both observe rather than direct child thought "without a preconceived idea of how a child must act or what psychological formula a child's behavior must exemplify" (Veer, 1967, p. 188). Both approach human behavior with an open mind, as the progressive development of their own theories attests. Each has had a number of "stages" or progressive changes of focus in their own investigations, but their overall aim has always remained constant - to further man's understanding of the development of his cognitive powers.

Basis of the Piagetian Model

Piaget thoroughly investigated the nature of child thought both by presenting various types of conceptual problems to his subjects and by acute observation of the spontaneous interaction of children with their environments. As has been previously noted he is interested in all facets of child development: speech cognition, perception, socialization, and moral principles. Thus he devised problems (some of which will later be described in detail in the Instruments section) designed to elicit information on

children's ability to work with numbers, time, mass, and area, as well as spatial and social relationships. On the basis of the resulting wealth of information accumulated, he formulated the overall scheme of cognitive development outlined below.

Several excellent comprehensive descriptions of Piaget's developmental stages are widely available (Baldwin, 1968; Flavell, 1963; Phillips, 1969), as are most of Piaget's original monographs, thus only a brief synopsis of his theory is included here.

A Brief Description of Piaget's Model of Cognitive Development

Piaget divides the route to mature thought into three major periods composed of stages, and occasionally sub-periods and substages. The structure of his developmental framework varies slightly from one publication to the next with regard to minor points; however, his overall position on cognitive change remains consistent. The version described herein adheres closely to his 1955 description, as this represents his most recent opinions on the matter. The earliest period is that of sensory-motor intelligence, which encompasses the time from birth to about two years of age. During this period the infant gradually advances from a purely reflex level of response to a state where he is aware of and responsive to his immediate environment and is able

to take direct action upon it at the concrete, purely perceptual level. The child becomes capable of primitive organization of action to solve immediate practical problems, but is not yet capable of any type of symbolism. Six stages and several smaller substages occur during this period; however, these will not be described in detail here as this earliest period is not of concern in the present study.

The second period is of lengthy duration (occurring between two and eleven years of age) and includes many important cognitive changes. This is the period of concrete operations, which is divided into two major sub-periods, the sub-period of pre-operational representations (encompassing between two and seven years of age) and the sub-period of concrete operations (from ages seven to eleven). The first sub-period includes three smaller stages--the beginnings of representational thought from two to four years, simple representations or intuitions from four to five and a half years, and articulated representations or intuitions from five and a half to seven years. During this pre-operational sub-period, the child learns to understand and use primitive symbols, thus "interiorizing" the world of action into thought operations. This is a time of symbolic practice and preparation, prior to entering the more sophisticated world of concrete operations. By the time the child has reached this second sub-period, he begins to display stable and

orderly adaptations to his environment. He is now able to organize simple cognitive structures into a coherent series or grouping and is at last in possession of co-ordinated, reversible systems of logical operation. The child's thinking becomes "mobile," and so loses the ego-centricity and perceptual dependence of earlier phases. He now relies primarily on perception, rather than the action-orientation of the sensory-motor period; however, both perception and thoughts are irreversible.

Piaget's final period is that of formal operations, which occurs after eleven years of age. At this level the child is not reality bound in his thought; he is able to conceptualize in the purely abstract world of hypothetical possibility. He is able to reason deductively and adds another dimension to his former concrete operations by now being able to convert them into propositions. Whereas the child in the concrete operations period is largely experience bound and can only extrapolate from the immediate situation in a very limited symbolic sense, the adolescent is capable of beginning investigation in the realm of abstract possibility, and then checking his hypotheses with real evidence.

Basis of the Vygotsky Model

In contrast to the multitudes of ingenious tasks devised by Piaget to provide insight into child thought, Vygotsky is known to have used only one method to assess

conceptual level in his subjects. This method is commonly known in western psychology as the "Vygotsky Blocks", or as the "Hanfmann-Kasanin Test", (renamed in honour of the psychologists who introduced Vygotsky's work to the English-speaking audience), or sometimes as the "Concept Formation Test." The test (which will be fully described in the Instruments Section of Chapter IV) consists of a number of geometric solids which are presented to the subject. One block is visibly coded with a nonsense syllable, but the coding on the others remains hidden. The subject is required to separate the blocks into four groups and provide his reasons for classification. If his first groupings are in error a further clue is provided by revealing the codes on another piece. This method is continued until the nonsense words gradually come to be defined by the characteristics of the blocks, and thus, a totally new concept is formed by the subject. This unique instrument was originally devised by Ach, but slight modification of the technique was made by Vygotsky and his co-worker Sakharov (Vygotsky, 1962).

Vygotsky administered this test to a large sample of children of various ages. As would be intuitively expected, response varied as a function of age level. On the basis of these findings, he formulated the model of conceptual development described below. This model corresponds closely to Piaget's system, notwithstanding the fact that each is

based on data gleaned from investigation of quite different areas of child behavior and problem solving. Unlike Piaget, who has largely confined his investigations to the juvenile mind, Vygotsky also researched adult conceptualization thoroughly. He was particularly interested in the manner in which mature thought can be impaired, so administered his Block Test to both brain-damaged and schizophrenic subjects as well as to normal adults. He found impaired thought more similar to that of children than of normal adults, and concluded it is possible both to progress and regress along his postulated developmental scale of cognitive sophistication.

Vygotsky's ideas are much less well known than those of Piaget, thus a relatively complete description of his developmental stages is included here. A thorough understanding of Vygotsky's terms is also of vital importance with regard to the later sections on scoring and interpretation of results.

Vygotsky's Model of Conceptual Development

Vygotsky divides ascent to mature concept formation (as measured by the Blocks Test or the method of "double stimulation") into three basic phases, which are in turn divided into several stages. During the first phase, performance on the blocks is characterized by arranging the pieces in "unorganized congeries" or "heaps" which consist of disparate objects grouped together without any apparent

basis for classification. This behavior suggests the meaning of the nonsense syllable is extended in a diffuse and undirected manner to include "inherently unrelated objects linked by chance in the child's perception" (Vygotsky, 1962, p. 59). Thus, at this level, words denote only a "vague syncretic conglomeration of individual objects that have somehow or other coalesced into an image" (p. 60), albeit a highly unstable one. A similar pattern occurs in other areas as well, including perception, thinking and acting. In these also the child tends to combine very diverse elements into one "unarticulated" image, on the basis of chance impression alone. Vygotsky believes such behavior is an attempt to compensate for "a paucity of well-apprehended objective relations" (p. 60) by relying on an "overabundance" of subjective connections. The child often tends to mistake subjective bonds for real ones; however, these primitive associations reflect a degree of reality insofar as they coincide with relations between the child's perceptions. As a result, many words have in part the same meaning to individuals at varied levels of conceptual development, particularly those referring to common concrete objects.

This first syncretic phase subsumes three distinct stages of performance on the Vygotsky Blocks. The most primitive stage of thinking involves purely random groupings, to which objects are added only on the basis of

guesses. When a guess is shown to be in error by examiner clue, the subject guesses again to replace it; hence, this level is known as the "trial and error stage." The second stage of sophistication is largely perceptual, as it is composed of groups determined primarily on the basis of the spatial position of the blocks. Here the subject forms a "purely syncretic organization" of his visual field as a result of spatial or temporal proximity. The third stage included in the first major phase involves more complex syncretic images, as groups are formed by taking elements from heaps already composed in the manner of the first or second stage. Higher sophistication rests solely on the fact that a two-step operation is involved, as the new combination has no intrinsic bonds, thus no more order than the simple assembling of heaps.

Progress to the next major phase occurs when "objects are united in the child's mind not only by subjective impressions but also by bonds actually existing between these objects" (p. 61). Vygotsky calls this second phase "Thinking in Complexes" and believes that to achieve it a child must be capable of differentiating between real and subjective bonds, so is growing from syncretism toward objective thinking. Complexes reflect coherent thought, but do not involve objective relationships in the more sophisticated fashion of conceptual thinking. The connections between the elements of a complex are concrete

and factual, rather than abstract and logical. These factual bonds are discovered through direct experience, but lack logical unity." A complex is therefore first and foremost a concrete grouping of objects by factual bonds" (p. 62). The primary difference between a complex and a concept is that the bonds of the former may be of many different kinds. "Any factually present connection may lead to the inclusion of a given element into a complex" (p. 62), while a concept is based on only one attribute.

Five basic types of complexes represent the stages of the second phase. The most primitive of these is the associative type, which is based on any bond the child forms between the sample and some other blocks. The sample forms the nucleus of the group, but connections made between the sample and other additions need not involve a common trait. Similarity, contrast, or proximity between pieces may each variously establish bonds. Vygotsky feels such groupings reflect a change in word meanings from designating a "proper name" of an individual object to representation of a "family name" of a group of objects related in many kinds of ways. The second stage of complexes resembles collections, as objects are placed together on the basis of characteristics that contrast with and complement the sample. Here one attribute is assumed to be the basis of grouping. This stage in the development of child thought is rooted in practical everyday experience where functional groupings

such as clothing or cutlery provide models of natural collection complexes. Association by difference is often combined with the earlier associative stage producing groupings rooted in mixed principles.

Vygotsky defines the collection complex as grouping on the basis of functional co-operation or participation in the same practical operation. Collections are followed by chain complexes, which involve "dynamic, consecutive joinings of individual links into a single chain with meaning carried over from one link to the next" (p. 64). The sample is not of central significance, and there is no consistency in the type of connection formed, as the decisive attribute keeps changing throughout the process. An element is included in the group on the basis of one characteristic, but is considered in terms of all its other attributes as well. In a concept, on the other hand, one trait is abstracted and considered specifically. Complexes do not include hierarchical organization as all attributes are functionally equal. Vygotsky considers the chain complex the purest form of Phase Two thinking, as it is perceptually concrete and factual. A complex does not rise above its own elements; it merges with the concrete objects that compose it. This fusion of general and particular is distinctively characteristic of all complexes, but particularly of those of the chain type. Chain complexes are vaguely defined, so often remote similarity suffices to create a bond.

The fourth stage in complex thinking is reached when the child forms diffuse complexes. This type involves fluid indeterminate bonds, and is sc indefinite as to be virtually limitless. The child stays within the limit of concrete bonds, but as the material cn the Vygotsky task differs from typical environmental objects, bonds are tenuously based on dim, unstable attributes. An example of this type of thinking would be choice of trapezoids to go with triangles, as they look like triangles with the tops cut off. Vygotsky considers "the surprising transitions" and "startling associations and generalizaticns" (p. 66) of children to be the real-life parallels of such performance on the Blocks.

The highest level of complex thinking is the pseudo-conceptual stage, so named because generalizations of this type phenotypically resemble mature concepts, but are based on concrete perceptually linked bonds. A pseudo-concept is formed when a child produces a grouping that could "just as well have been assembled on the basis of an abstract concept" (p. 67). Vygotsky is of the opinion that pseudo-concepts predominate over all other complexes in the pre-school child's life because "ccmplexes corresponding to word meanings are not spontaneously developed by the child. The lines along which a complex develops are predetermined by the meaning a given word already has in the language of adults" (p. 67). Thus the stable, permanent, everyday meaning of a word is communicated to the child, whc fcrms a

complex around it. Vygotsky considers complexes and concepts functionally equal, as pseudo-concepts provide a connecting link between the two in the form of "a complex already carrying the germinating seed of a concept" (p. 69). Verbal communication is a powerful factor in conceptual development, but only because the prevalence of pseudo-concepts permits understanding between individuals at different levels of conceptual sophistication. The child himself is typically unaware of the change from complex to conceptual thinking, as pseudo-concepts are not just a fleeting phenomenon elicited by the Blocks test, but a genuine "genetic" development that may be readily observed in everyday life. Vygotsky concedes that the forms of concrete thinking so clearly differentiated by Blocks performance "often appear in reality in mixed states."

Another trait that illustrates the difference between pseudo and true concepts is the "participation" phenomenon which has been noted to occur in the thought patterns of children, schizophrenics and primitive peoples. Participation is the relationship of partial identity formed between two objects or events that appear to have no recognisable connection to the completely conceptual mind. The bonds formed are clearly unacceptable to adult logic, and involve concrete images rather than abstract concepts. Vygotsky believes the history of languages illustrates that complex thinking is the foundation of linguistic

development.

Vygotsky views the complex thinking of Phase Two as one root of concept formation, but feels the type of thinking found in Phase Three represents a second, independent root. In reality, Phase Three formations appear in rudimentary form long before the Phase of Complexes has run its course, but they are considered to be a higher level of development as a degree of abstraction is required. Complexes unify scattered impressions with bonds and relationships, and as such create a basis for the more advanced generalizations of Phase Three. Abstraction requires singling out elements and viewing them apart from the total concrete entity; thus, genuine concept formation requires separation and unification. Complex thinking cannot both synthesize and analyze, as it by nature involves an overabundance of connections.

The first stage of the third phase of conceptual development occurs in Blocks performance when the child groups together maximally similar objects. The test contains no identical blocks; therefore, the members of each group are dissimilar in many respects. This implies that the child is paying more attention to some traits than others, such that this preferential treatment has breached hitherto global perception of the materials. Performance of this type represents the beginnings of positive and negative abstraction.

The next stage, designated "potential concepts," involves grouping on the basis of a single attribute. Again the product is indistinguishable from that obtained from true conceptual thinking, but Vygotsky considers it a precursory stage, as it involves only primitive isolating abstraction. Potential concepts may be formed in the perceptual sphere on the basis of similar impressions or in terms of practical action bound thinking on the basis of similar functional meanings. Vygotsky notes that "potential concepts already play a part in complex thinking but in so far as abstraction occurs, also in concept formation" (p. 78). However, in the latter instance the trait is not easily lost amongst other traits once abstracted. At the complex level, the abstracted element is unstable and loses temporary dominance to other traits. "Only the mastery of abstraction, combined with advanced complex thinking, enables the child to progress to the formation of genuine concepts" (p. 78). The decisive role in this process is played by words, which direct "all the part processes of advanced concept formation" (p. 78).

The final stage of concept formation is reached during adolescence, when primitive patterns gradually give way to true concepts. The adolescent does not immediately cease to use earlier thought forms upon discovery of true concepts, indeed the former may not predominate many areas of thinking for some time. Vygotsky describes adolescence as a

period of crisis and transition rather than completion. Even the normal adult, capable of the highest level of conceptualization, cannot consistently be relied upon to operate at this level at all times. The transitional character of adolescent thought is evidenced by a striking discrepancy between ability to use concepts and to define them. Vygotsky feels this discrepancy, which can also be noted in adult thought, "confirms the assumption that concepts evolve in ways differing from deliberate conscious elaboration of experience in logical terms. Analysis of reality with the help of concepts precedes analysis of the concepts themselves" (p. 79). Vygotsky also describes other characteristics of adolescent thought that cannot be directly observed in the context of the Blocks performance itself. At a "fairly early stage of development," the adolescent learns to transfer a concept learned in regard to one set of circumstances to a new situation. Much more difficult, however, is defining the concept on the purely abstract plane, apart from the original circumstances and other concrete referents. In such a case the individual often resorts to more primitive modes.

Vygotsky's overall view of concept formation is of "movement of thought within the pyramid of concepts, constantly alternating between two directions, from the particular to the general and from the general to the particular" (p. 80). He feels concepts are developed not

merely through "interplay of associations" but as a result of an "intellectual operation in which all elementary functions participate in a specific combination" guided by the use of words as a means of centering attention, as well as abstracting, synthesizing and symbolizing traits. A diagramatic representation of both of the theories involved in the present study follows.

COMPARATIVE DIAGRAM OF THE THEORIES OF COGNITIVE DEVELOPMENT OF J. PIAGET AND L. S. VYGOTSKY

VYGOTSKY'S MODEL	PIAGET'S MODEL
	Period of Sensory Motor Intelligence (birth to 2 years)
Phase of Syncretic Images Trial and Error Stage Perceptual Stage Composite Stage	**Period of Concrete Operations (age 2 to 11)** Subperiod of Pre-Operational Representations (age 2 to 7) Stage of Representational Operations (age 2 to 4) Stage of Simple Representations (age 4 to 5 1/2) Intuitive Stage (age 5 1/2 to 7)
Phase of Complexes Associate Stage Collections Stage Chaining Stage Diffuse Stage Pseudo-conceptual Stage	Subperiod of Concrete Operations (age 7 to 11)
Phase of Concepts Stage of Maximal Similarities Stage of Potential Concepts Stage of Genuine Concepts	**Period of Formal Operations (age 11 years on)**

Studies Based on Vygotsky's Work

The majority of the experimental studies inspired by Vygotsky's work have investigated the use of his Blocks test as an instrument of clinical diagnosis, in the hope that the test would prove a simple and sure method of differentiating between normal and abnormal thought patterns (Hanfmann and Kasanin, 1937, 1942; Kasanin and Hanfmann, 1938; Hanfmann, 1940; Bolles and Goldstein, 1938; Bolles, Rosen and Landis, 1938; Cameron, 1939; Aldrich, 1944; Des Lauriers and Halpern, 1947; Fisher and Seymour, 1950; Penny, 1951; Lovibond, 1954; Pickford and Pickford, 1943). The relationship between Vygotsky performance and various personality traits has also been explored in this connection (Hanfmann, 1941; Rapaport, 1941, 1942, 1968; Fisher, 1950; Norman, Baker and Doehring, 1950; Miller, 1965). This subsequent research has largely supported Vygotsky's original contention that various patient groups perform in a significantly different manner from a normal sample on the Blocks, but the instrument was not found to be sufficiently sensitive to diagnose accurately in the individual case. Although generally deemed unsuitable for individual clinical diagnosis, researchers and reviewers alike felt the test offered a unique and effective method of revealing the level of cognitive development. Thus it seems the Vygotsky Blocks are ideally suited to genetic studies; however, very few have been attempted to date.

Thompson (1941) included the Blocks test in an investigation of children's ability to generalize concepts at various age levels. She concluded the Vygotsky Blocks "permitted excellent qualitative analysis" of the types of problem approaches used by children (p. 67). Characteristic performance patterns were ncted for the different ages tested (six to twelve years). Younger children tried to solve the problem using a single hypothesis, and as expected, the number of approaches attempted increased as a function of age. The nature of the children's responses suggested that the difficulty of the task lay in the fact that solution requires simultaneous attention to two crucial perceptual aspects of the material.

Des Lauriers and Halpern (1947) also used the Blccks test as part of a larger battery, but in this case the subjects were schizophrenic rather than normal children. Performance on the Blocks was found to be grossly affected by emotional factors, as these children apparently viewed the task as an "unsolvable situation from which they must escape" (p. 65). On the whcle, disturbed subjects were unable to organize an effective approach to the task, even with examiner assistance.

Meece and Rosenblum (1965) are the only investigators to date who have published a study dealing exclusively with developmental variables reflected by performance on the Vygotsky Blocks. Their subjects were 50 sixth grade girls

(between 11 1/2 and 12 1/2 years old) with a mean IQ of 99.3 and a mean mental age of 11 years 9 months. Administration of the test was presumably similar to Vygotsky's original method, with the addition of timing variables, and a quantitative scoring system. Results yielded a significant correlation between mental age and level of sophistication of the subject's verbal statement of the principle involved in solution. Subjects who had difficulty stating the concept usually required more clues and took a longer time to reach solution. A significant correlation was not established between mental age and "maturity" of spontaneous groupings; however, most subjects at the higher levels chose form rather than the more primitive color variable as a basis for first groupings. On the whole the brighter subjects needed less time and fewer clues than their less intelligent companions; however, differences between the two groups were not significant. Analysis of Vygotsky task variables was carried out to determine which could best predict mental age. Verbal proficiency emerged as by far the most important factor. Norming procedures were also carried out, with the result that sixth grade girls were found to perform very much like adults on the Blocks test.

Stones and Heslop (1968) devised an ingenious experiment designed to test the generalizability of the concepts formed during the Blocks Test. They administered the Vygotsky Blocks to sixty primary school children (ten at

each grade level) and then asked the children to classify pictures and clay figures in terms of the four test groupings. The subjects were also asked to define the nonsense syllable naming each group and to model a box out of clay to fit each category. Results of this research support Vygotsky's findings, as all levels of performance described by Vygotsky were observed here as well. As was expected, primitive responses decreased in frequency as a function of age, and true conceptual thinking was totally absent at six years and gradually reached 43 percent of the total responses by eleven years. Ability to function at the highest levels was also found to be related to intellectual ability. As Vygotsky predicted, ability to correctly regroup the blocks improves with age, thus regrouping could be readily accomplished by conceptual subjects but not by the "pre-complexive" or lowest level group. Phase One and Two level thinking was found to correlate negatively with extension test successes, usually at a highly significant level. Conversely, conceptual thinking correlated highly significantly with extension test scores. This study is of prime importance to Vygotsky's theses, as it clearly demonstrates that true, meaningful concepts which may be widely utilized are formed as a result of the Vygotsky task.

As the follow up to the preceding experiment, Stones (1970) again administered the Vygotsky blocks to 60 children (20 aged 7 years, 20 aged 9 and 20 aged 11), but this time

half the sample used test blocks with no nonsense syllables on them. All S's were then given extension tests similar to those of the earlier study, requiring grouping of pictures and three dimensional objects. It was found that all S's had little difficulty regrouping the blocks after the test regardless of age or experimental condition. There was a slight tendency for older children to score higher on the object sorting task, but on the whole subjects using labelled blocks performed much better than the other groups. In picture sorting as well, the "labelled" experimental group scored much higher. Stones concludes from these findings that the "use of verbal labels facilitates the learning of concepts" (p. 252) and that ability to resort the blocks following the Vygotsky Test reflects more immediate recall visual memory than true comprehension of the concept involved. This experiment supports Vygotsky's view that language plays a fundamental role in concept formation, a position also espoused by Piaget.

Thus Vygotsky's developmental findings have largely been supported by subsequent child research, but work in the area has only barely begun. Further validation of his developmental stages is sorely needed, using samples of children of all age levels.

None of the aforementioned studies report any significant differences between male and female performance on the Vygotsky test. This is in keeping with other

research findings on adult subjects.

Studies Based on Piaget's Work

Piaget's discoveries have inspired a wealth of further research designed to provide information concerning the validity and generality of his observations of child thought processes, and of his proposed stages of conceptual development. To date the majority of these studies have been of the simple replication type; although most investigators have attempted to relate obtained results to other variables in the hope of discovering crucial elements involved in the realization of higher conceptual performance in various cognitive areas. Efforts have also been made to accelerate mental development with specialized training, primarily to discover if such a feat is indeed possible, and secondarily to ascertain what types of skills (if any) benefit intellectual growth. Cross cultural studies have been carried out as well for purposes of determining if Piaget's findings are truly representative of human development in general. Research has been undertaken into many aspects of Piaget's theory, including class inclusion, animism, causality, reversibility, perception and moral development; but by far the most investigation has been centered on his conservation tasks. Since these conservation tasks are to be used as the primary measures of developmental sophistication in the present study, this topic shall be the focus of concern here.

Conservation has received the bulk of research attention to date because it has the two-fold advantage of being a vital cornerstone of Piaget's developmental theory and of being a readily investigated topic. Conservation is a very simple concept, so rudimentary in fact that prior to Piaget it was taken for granted that everyone was capable of using it. Thus psychologists (and the world in general) were amazed when Piaget announced that many young children did not understand the "principle of invariance". These youngsters thought that a given quantity of material changed in amount when its spatial configurations were altered; hence they did not "conserve" the amount. However, as children grew older they came to realize, for example, that a plasticine ball flattened into a pancake still involves the same amount of plasticine regardless of appearances; thus they were capable of conserving or operating in terms of the principle of invariance. Piaget discovered that this phenomenon applied to a variety of different materials and properties, to the mass, weight and volume of plasticine balls changed into various shapes, to liquid substances poured into different shaped containers, to small beads treated likewise. Further, it applied to problems involving different configurations of the same number of objects, surface area covered or density of a material. Piaget's extensive experimentation led him to conclude that the ability to conserve represents a sufficiently major change

in the child's cognitive processes that performance in this area alone may be considered an excellent indicator of his level of overall intellectual development. In Piaget's own words, "conservation is a necessary condition for all rational thought" (1953, p. 3).

The relationship between conservation performance and developmental stage is described more fully in the Method section of Chapter IV. Piaget's most extensive discussions on the topic of conservation are to be found in Piaget (1947,1970), Piaget and Szeminska (1952), and Piaget and Inhelder (1962,1966).

Replications of Piaget's conservation work (involving widely diverse subject populations) have been carried out by the following investigators, in the noted content areas:

(1) Conservation of Continuous Quantity

Freyberg (1966); Pratoomraj and Johnson (1966); Farnham-Diggory and Berman (1968); Price-Williams, Gordon and Ramirez (1969); Halford (1969); Peisach and Wein (1970); Lloyd (1971); O'Bryan and Boersma (1971); Elkind and Schoenfeld (1972); Gelman and Weinberg (1972); Green and Laxon (1972); Gruen and Vore (1972); Hardemann (1972); Brainerd and Brainerd (1972); Little (1972).

(2) Conservation of Discontinuous Quantity

Estes (1956); Dodwell (1960); Feigenbaum (1963); Freyberg (1966); Mermelstein and Shulman (1967); Halford (1968); Silverman and Schneider (1968); Hooper (1969); McManis (1969b); Peisach and Wein (1970); Papalia and Hooper (1971); Little (1972).

(3) Conservation of Mass

Vinh-Bang (1959); Lovell and Ogilvie (1960); Uzigris (1964); Overholt (1965); Goodnow and Bethon (1966); Pratoomraj and Johnson (1966); Keasey and Charles (1967); Hall and Kingsley (1968); Price-Williams, Gordon, and Ramirez (1969); Simpson (1970); Batt-Haee (1971); Towler and Wheatley (1971); Elkind and Schoenfeld (1972); Papalia (1972); Tobin (1972).

(4) Conservation of Weight

Vinh-Bang (1959); Lovell and Ogilvie (1961a); Uzigris (1964); Furth (1964); Freyberg (1966); Goodnow and Bethon (1966); Griffiths, Shantz and Sigel (1967); Hall and Kingsley (1968); Batt-Haee (1969); McManis (1969); Simpson (1970); Price-Williams, Gordon, and Ramirez (1969); Towler and Wheatley (1971); Gruen and Vore (1972); Papalia, (1972).

(5) Conservation of Volume

Ving-Bang (1959); Lovell and Ogilvie (1960); Lunzer (1960); Uzigris (1964); Goodnow and Bethon (1966); Archenbach (1969); Batt-Haee (1969); Simpscn (1970); Phillips (1971); Brainerd (1971); Towler and Wheatley (1971); Bright (1972); Papalia (1972); Little (1972).

(6) Conservation of Number

Estes (1956); Dowell (1960); Freyberg (1966); Griffiths, Shantz and Sigel (1967); Bever, Mehler and Epstein (1968); Peters and Rubin (1969); Rothenberg (1969); Rothenberg and Courtney (1969); Halasa (1967); Baker and Sullivan (1970); Green and Laxon (1970); Calhoun (1971); Cathcart (1971); Lloyd (1971); Papalia and Hooper (1971); Elkind and Schoenfeld (1972); Gruen and Vore (1972); Hardeman (1972); Papalia (1972).

(7) Conservation of Length

Lovell, Healey and Rowland (1962); Delacey (1967); Murray (1967, 1968a,b); Griffiths, Shantz and Sigel (1967); Pratoomraj and Johnson (1966); Hall and Kingsley (1968); Archenbach (1969); McManis (1969a); Larsen and Flavell

(1970); King (1971); O'Bryan and Boersma (1971); Elkind and Schoenfeld (1972).

(8) Conservation of Distance

Lovell, Healey and Rowand (1962); Shantz and Smock (1966); Pratoomraj and Johnson (1966).

(9) Conservation of Area

Murray (1968a); Archenbach (1969); O'Bryan and Boersma (1971).

(10) Conservation of Density

Brainerd (1971).

(11) Conservation Studies Using a Variety of Tasks

Elkind (1961a, b, c, d); Goldschmid (1967, 1968); Goldschmid and Bentler (1968); Papalia and Hooper (1971); Harasym, Boersma and Maguire (1971); Tisher (1971); Wasik and Wasik (1971); Elkind and Schoenfeld (1972); Fleck (1972); Gaudia (1972); Moynhan and Glick (1972).

On the whole, these studies provide solid support for Piaget's model of age dependent cognitive development and his related theoretical constructs; however points of dissention have naturally arisen, which will be included in the following discussion. The aforementioned papers which are not referred to below may be assumed to be in support of

Piaget's position.

Piaget's findings reveal some variation in the average ages of attainment of conservation in different content areas - conservation of matter is achieved at approximately 6 1/2 to 7 years; conservation of length - 7 to 8 years; conservation of continuous quantity (solids and liquids) - 7 to 8 years and conservation of volume - 11 to 12 years. The vast majority of later investigators agree with Piaget's postulated ages of conservation attainment for various tasks, but there has been some contradictory evidence, particularly regarding conservation of number.

Estes (1956) was the first to report the occurrence of successful number conservation in children much younger than Piaget's proposed minimum age (4 years as opposed to 6 1/2 to 7); but replication of Estes' work with a larger sample soundly refuted such claims (Dodwell, 1960). Braine (1964); Braine and Shanks (1965); and Bruner (1965) also reported successful conservation of number by preschool ildren. However these investigators used different criteria as evidence of success, so it is a moot point whether their findings may be legitimately compared with those of Piaget. Braine and Bruner use a modification of Piaget's assessment techniques, as well as defining conservation in slightly different terms, and on this basis estimate that conservation begins about five years of age rather than seven. This position is supported by Green and Laxon (1970)

and King (1971). Braine justifies these modifications on the basis that a five year old has the cognitive skills necessary to handle conservation problems, but cannot demonstrate this because he cannot understand the precise meaning of the questions posed until he is seven. Piaget, on the other hand feels the child cannot be considered a conserver until he is able to put the knowledge to use under the ordinary circumstance of verbal communication. Thus it would appear that their actual findings agree, only their interpretations differ.

In 1967, Mehler and Bever reported that they had discovered successful conservation of number in children below four years of age, and felt their findings refuted Piaget's position on his own grounds. Is resulted in an immediate flurry of controversy, and immediate additional studies. Beilin (1968) replicated their study, and concluded that conservation responses in three and four year old children occur at chance level only. Not one of his subjects was correct on all three equality tasks, and only 7 per cent were successful on the conservation of inequality tasks, which are usually considered simpler than the traditional Piagetian equality queries. Beilin concluded that young children have very little conservation ability, but they do demonstrate some of the necessary conceptual capacities. However, without the vital inference generating mechanisms of older children, their understanding is

severely limited. Mehler and Bever reported that conservation performance declined somewhat following success at the 3-4 year level. No evidence for this pattern was found by Beilin.

Bever, Mehler and Epstein (1968) felt that Beilin's study cannot be considered a true replication of their work, owing to methodological variations. They proceeded to bolster their position by stating that the basic cognitive structures necessary for conservation are available even to the two year old, but unfortunately the child is unable to use them efficiently at this age! Belin's reaction to this (1968) was to point out that two year olds are responding in terms of perceptual arrangements, not cognitive structures; and Piaget himself had the last word when he suggested that the findings of Bever, Mehler were most interesting, but "they have nothing whatever to do with conservation" (1968, p. 976).

Rothenberg (1969) found only 6 per cent of 210 preschool children were able to conserve number, and over half of the sample never achieved even one correct response. Rothenberg and Courtney (1969) went on to investigate conservation of number in two to four year olds, and found conservation was "very infrequently" attained; however associated skills were noted. Even when less stringent criteria were used, conservation was not found to any appreciable extent. Rothenberg and Courtney accuse Mehler

and Bever of inadequate methodology, errors in initial assumptions, and biased questions. They feel that their results strongly support Piaget's claim that conservation of number is not a reality until about 6 or 7 years of age, and note that the findings of Elkind (1961), Gruen (1965), Hood (1962), and Wohlwill and Lowe (1962) concurr, as do Papalia's (1972). Only one study provides even mild support for Mehler and Bever's position. Calhoun (1971) feels his results are "generally" comparable to theirs, but notes that the youngest subjects could not follow instructions properly. No verbal responses were required here, thus the methodology employed differs considerably from Piaget's.

Elkind's (1961) results agree with Piaget's findings as regards conservation of mass and weight, but only 27% of the 11 and 12 year olds, 47% of the high school students and 58% of the college subjects tested showed evidence of an abstract concept of volume. Uzigris (1964), Simpson (1970), and Papalia (1972) also found conservation of volume occurs largely after 12 years of age. This suggests that perhaps Piaget's postulated age of attainment of conservation of volume at 11-12 years is rather premature. Thus Towler and Wheatley (1971) tested college subjects on questions of interior and occupied volume, and proposed that difficulties in this area are due to an inaccurate concept of atomism, since erroneous responses most often referred to molecules, density and such. Hall and Kingsley (1968) found that 26%

of psychology upperclassmen and 29% of psychology graduate students could not conserve volume. Bright (1972) administered volume problems to various groups of education students in college and found percentages of conservers varied from 49 to 85 on initial testing. On the other hand, Piaget's position on volume has been supported by the findings of Lunzer (1960), Lovell (1961), Lovell and Ogilvie (1961) and Batt-Hall (1971).

Delacy (1967) is the lone dissenter regarding conservation of length, which he feels is achieved later than Piaget suggests. However, in this case Piaget uses the less stringent criteria, as he bases his estimations on first appearance of conservation, rather than Delacy's "age of reliable measurement". Thus, Piaget's findings as regards conservation attainment are well supported by later research and appear to withstand all criticism well, with the possible exception of the universality of the concept of volume. However, more research is needed into this question before final conclusions can be drawn.

Piaget accounts for the fact that different conservations are attained at different age levels with the concept of horizontal decalage, which he describes as "variation in ability to solve different types of problems apparently mediated by the same cognitive structures." (1963). Wohlwill (1966a) notes that this is an essential ad hoc notion, which has never been adequately incorporated

into Piaget's theory, nevertheless only a very few investigators have suggested that these variations do not exist. Archenbach (1969) found no evidence of horizontal decalage for both retarded and normal subjects, as all subjects performed about equally well on all types of conservation whether verbal scores or simple number conservation responses were considered. Braine and Shanks (1965) found similar results with a sample of normal ability levels. Gruen and Vore (1972) found more decalage in the responses of retardates than in normal controls. In contrast, even some investigators who have disagreed with Piaget on other points support his position on decalage. Simpson (1970) found his norms re attainment of volume concurred more with those of Elkind and Uzigris than with those of Piaget; but he supports Piaget's position on decalage and invariant space (essentially order of difficulty of the tasks). King (1971) goes along with Braine and Bruner that verbal criteria are not the only, or even the best, indications of conservation; however he too agrees with Piaget concerning decalage.

Piaget's conservation experiments dealt mainly with normal children, thus he discusses the topic largely in terms of chronological age. His co-worker Barbel Inhelder was the first to relate conservation to mental age, as she investigated the performance of retarded children on conservation tasks. These studies showed that conservation

was more closely related to mental than chronological factors, as the retarded subjects were found to pass through exactly the same stages of cognitive development as others, but at a slower rate. The work of Carpenter (1955), Woodward (1959, 1961), Elkind (1961), Feigenbaum (1969), and Goodnow and Bethon (1966) supports this conclusion. Only Dodwell (1961) found no differences in performance among different I.Q. levels on conservation of quantity and amount. Little (1972) initially found chronological age related more closely to Piagetian performance than mental age in four and five year old subjects, but further research revealed mental age is of greater significance at six to seven years.

Feigenbaum (1963) and Hood (1962) suggested I.Q. might be more vital than mental age, if the performance of younger, brighter children exceeded that of older duller ones. The findings of Gruen and Vore (1972) support this idea, but those of Goodnow and Bethon (1966), and Keasey and Charles (1967) argue for equal performance for equal mental age. Goodnow and Bethon also found that Piaget's tasks differentiate between children of limited, average and superior intellectual ability, and that even a single task can accurately differentiate dull from average subjects. These discoveries concur with the extensive work of Laurendeau and Pinard (1962), who have been working for some years on a new form of intelligence test based on Piagetian

principles.

The relationship between conservation performance and mental age is in keeping with Piaget's belief that educational experience is not a crucial factor in cognitive development. Even the more difficult tasks which would intuitively seem to be based on school learning, (such as those of weight, volume and surface area), were found by Sigel and Mermelstein (1965) and Goodnow and Bethon (1966) and Papalia (1972) to be quite insensitive to educational variations. These researchers did caution that extremely poor schooling might well lower cognitive development, particularly as regards combinatorial type tasks requiring a great deal of mental work and little concrete manipulation. However, they conclude that in the normal course of events, children acquire the skills needed for conservation without benefit of schooling.

Additional evidence for Piaget's position on the role of educational variables is provided by the many cross-cultural investigations that have been carried out. Conservation studies using children from the African bush (Price-Williams, 1962), Hong-Kong (Goodnow and Bethon, 1966), Yoruba (Lloyd, 1971) and Mexico (Price-Williams, Gordon and Ramirez, 1969) to name but a few, all support Piaget's findings. Peluffo (1967) in his review of cross-cultural work, concludes that attainment of concrete operations is a universal phenomenon. Price-Williams <u>et al</u>

found that children of Mexican potters attained conservation in the same manner as others, with the exception of conservation of substance, on which they performed much better. They conclude that perhaps manipulative skill is an important variable here, especially when the skill yields a recognizable end product. Cultural factors and general life experiences do seem to play a larger role in cognitive development than formal education. As Wasik and Wasik (1971) and Gaudia (1972) found, disadvantaged children take one to two years longer to acquire the various conservations, and Lloyd (1971) found social class to be a significant variable in both American and Yoruba children, particularly as regards number conservation. Mermelstein and Shulman (1967) compared the performance of educated and uneducated Negro children, and found no significant difference in quantity conservation on both verbal and non-verbal criteria. Hyde (1959), Peel (1959), Wohlwill (1960a), Lovell and Ogilvie (1961b), Hood (1962), Duckworth (1964), and Smedslund (1964a), all concluded that a wide range of experiences in play etc. yield conservation, as opposed to any specific training or skill, which supports the hypothesis that overall culture would affect conservation but schooling per se would not.

Research has rendered conservation virtually an undisputed universal fact, but it remains as yet a little understood phenomenon in the eyes of many theorists. Thus,

there has been a good deal of speculation as to the factors involved in conservation acquisition. Piaget maintains that a non-conserver is able to reason adequately about a given static stimuli, but cannot comprehend transformations in material; therefore a pre-operational child is not capable of "reversibility" of thought. Since reversibility is lacking, the child does not realize that change in one dimension may be compensated by an equal and opposite change in another aspect; hence the child cannot deal with simultaneous changes. Piaget feels reversibility is caused by decentration, which occurs when the child is able to draw his attention away from one overwhelming perceptual aspect to other less obvious, but more relevant cues. Piaget considers that the transition from non-conservation occurs in three stages (1947, 1959). Initially the child bases his reasoning on changes in a single dimension of the stimulus. Later he becomes cognizant of more than one relevant aspect, and finally, he is able to systematically scan complementary dimensions and thus operate via the principles of compensation, reversibility and identity. Other possible interpretation of conservation have been proposed. Bruner (1964, 1966) suggests that three representational systems are involved; Wohlwill (1962) believes tolerance for irrelevant information is crucial; and Staats and Staats (1964) Watson (1968), and Berlyne (1965), have used various S-R models to explain conservation. Little research attends

these theories as yet. Piaget's hypotheses, however, have been well supported by later investigation.

Smedslund (1963b) felt perceptual cues play a negligible role in conservation, but later researchers disagree. Both Frank (1966) and Murray (1967) found perceptual variables to be of vital significance at younger age levels, with gradual decrease in importance as age advanced. O'Bryan and Boersma (1971) measured the eye movements of conservers and non-conservers. They found clear evidence of perceptual decentration, as the patterns of the two groups differed significantly.

Piaget suggests ability to compensate (for a change in one dimension by attending to a complementary change in a corresponding aspect) precedes full conservation, but Acker (1968) found a much higher percentage of conservers who failed to compensate than the five per cent reported by Inhelder and Piaget. Lee (1971) also considers compensation to be more difficult than conservation; however Larson and Flavell (1970) describe their findings on the question as "equivocal". Gelman and Weinberg (1972) caution that the relationship between conservation and compensation varies depending on the experimental method employed. On a single task conservation always appeared to be easier, but over several problems all conservers demonstrated ample evidence of compensation. These investigators suggest that the ability to verbalize compensation develops later than that

for conservation, however Cohen (1967), Piaget (1952), Piaget and Fraisse (1952), Halford (1969) and King (1971) found that non-conservers could successfully predict the effect of material transformations before the change is actually made, which seems indicative of compensatory skill. Further, Farnham-Diggory and Berman (1968) hypothesize that children do not base judgements on aspects that they cannot code verbally. Thus from this point of view, those who can reason in terms of compensation should be able to verbalize it. Green and Laxon (1970) do not consider compensation a necessary prerequisite to conservation as they feel it is rarely mentioned in children's spontaneous explanations of such problems. Cathcart however, found compensation solutions were second in popularity and were mentioned more frequently than reversibility (1971). This study revealed that identity arguements are the most popular and tend to be used mostly by partial conservers, whereas full conservers relied more on reversibility. Thus, these results support Piaget's hypothesis that compensation developmentally precedes reversibility and fully logical thought. King (1971) found compensation (as evidenced by the prediction tasks) to be a necessary but not sufficient condition for conservation, which is also in keeping with Piaget's position.

Harasym, Boersma and Maguire (1971) discovered that conservation and ability to distinguish both qualitative and

quantitative differentiations develop simultaneously. Halford (1968, 1969) learned that non-conservers can judge quality on the basis of logical criteria, thus he concludes that a rudimentary classification system is constructed by the child prior to operational thought. Further research revealed that this system gradually gains sophistication, culminating in a true conceptual stage at about seven years of age. This supports Piaget's ideas that conservation is gradually acquired, reaches fruition at seven years, and that it is based on logical constructions on the part of the child. However, Halford believes these findings go somewhat beyond Piaget as they raise the possibility that logical constructs may originate in the pre-operational child. In view of the fact that Piaget has always believed strongly that each stage builds on the rudiments of the preceding one, the two positions would seem to be only slightly discrepant.

Elkind (1961) first raised the possibility that children should be able to conserve the identity of a single object under transformation before they do so in the traditional Piagetian conservation problem, which involves comparison of two objects and a subsequent change in only one of them. The former type was then labelled "conservation of identity", the latter "conservation of equivalence". Research be Murray (1968b), Hooper (1969), McManis (1969b), and Bright (1972) supported the idea that

conservation of identity preceded that of equivalence in a given content area. However, the work of Northman and Gruen (1970), Moynahan and Glick (1972) and Piaget himself, contradicts the idea. Further investigation by Elkind and Schaenfeld (1972) confirms their earlier position, particularly in the case of younger children. Thus Elkind suggests that different mental processes may be involved in conservation at different age levels. McManis believes that identity concepts not only precede equivalence, but are a necessary condition for full conservation. However, he found that not all children show evidence of identity conservation. Papalia and Hooper (1971) found that conservation of identity preceded that of equivalence in the case of quantity, but not of number. These rather contradictory findings suggest further experimentation is needed to clarify the occurrence and significance of identity conservation.

Piaget's "clinical method" of experimentation has often been criticized by other researchers who have found that variations in testing materials, questions posed and such influence obtained results (Lovell, Healey and Rowland, 1962; Uzigris, 1964; Goldschmid , 1967; Baker and Sullivan, 1970; and Gelman and Weinberg, 1972). Piaget's rather free form approach tc research is defended by Mermelstein and Shulman (1967) and several other cross-cultural investigators who point out that Piaget's stages

are repeatedly confirmed under many varying circumstances. Thus, they reason, specific assessment techniques play only a minor role. Peter and Rubin (1969) investigated the question carefully and concluded that variations make a difference to some subjects, but not to others. Over a whole sample of subjects they found very little difference in scores resulted.

The vast majority of Piagetian studies to date do not report differences in performance by males and females, however Goldschmid (1967) found boys attained slightly higher scores. Papalia (1972) notes that males do somewhat better than females among children and young adults, but females gain superiority among the more elderly.

In conclusion, replications of Piaget's conservation work largely support his findings and the majority of his interpretations, but raise many interesting theoretical queries, particularly concerning the variables underlying conservation attainment. Piaget's concepts of identity, reversibility and such seem well supported, but it will be interesting to compare his model with others when more investigation has been carried out on alternative hypotheses.

The Lone Experiment Involving Both Piaget's and Vygotsky's Theories

Only one study to date has attempted to compare the work of Vygotsky and Piaget, albeit on a rather indirect

basis. This study was carried out in 1972 by Denney, and involved a comparison of "free classification procedures" similar to those used by Vygotsky and Inhelder and Piaget. The tasks devised were administered to eight male and female children aged 2, 4, 6, 8, 12, and 16 years, selected on a random basis. The stimuli developed for purposes of this experiment were a set of 38 wooden blocks which varied in color and shape. In the "free grouping procedure" (based on Piaget's classification tasks) the subjects were told to group the blocks in any way they wanted. In the "verbal labelling procedure" (based on Vygotsky's work) the subjects were shown one block identified by a nonsense syllable and asked to find all other blocks that might be the same type. Obviously the verbal labelling procedure is considerably more difficult than the free classification tasks. Thus, it is hardly surprising that Benney found different types of responses offered for each. Indeed, neither theorist has ever claimed any similarity between their classification tasks or the results found from them as Denney acknowledges. Vygotsky's Blocks are much more than a straight-forward classification task, as they involve step by step solution to a highly specialized problem requiring logical deduction and simultaneous attention to several perceptual variables. Piaget, on the other hand, has investigated only the development of simple spontaneous classificatory ability. While he has noted the general patterns of increasing

sophistication in this area, Piaget has never considered classification performance alone to be reliably indicative of overall cognitive level, in the manner of Vygotsky's blocks.

Denney expresses surprise that "neither Vygotsky's nor Inhelder and Piaget's results were "replicated" and that "developmental stages such as those reported by Vygotsky and Inhelder and Piaget were not obtained" (p. 221). Rather than a surprising finding, these results would be better considered a foregone conclusion, in view of considerable deviation in experimental methods from those used in the original studies. Denney's stimuli appear similar to those of Vygotsky (although the comparability can only be roughly guessed) but quite different from Piaget's materials. The questions posed to the subjects are close to those of Piaget, but are vastly at variance with Vygotsky's thorough procedure. Thus, the real question involved in this research is the relationship between the devised procedures and the original tasks of Vygotsky and Piaget. Until this point is fully explored the implications of Denney's results on the developmental theories of Vygotsky and Piaget cannot be meaningfully assessed. Denney's study makes the error of comparing a relatively minor aspect of Piaget's theory with the major basis of Vygotsky's entire model of cognitive development. The present investigation was designed to compare the two theories on a more equal basis.

Chapter III

Hypotheses

The primary purpose of the present study is to compare the performance of a representative sample of children aged 4 - 14 years on cognitive problems devised by L. S. Vygotsky and J. Piaget. In addition, results regarding each specific conceptual task will be compared with those of other investigators.

Thus, the following hypotheses will be considered:

H_1: Knowledge of level of performance on Piagetian tasks permits accurate estimation of corresponding Vygotsky developmental stage.

H_2: Number of children scoring at higher task levels and thus at higher developmental stages increases as a function of higher mental age.

H_3: Children of a given age level perform significantly differently from those of other age levels on the cognitive tasks in the present battery.

H_4: Success levels of males and females do not differ significantly for any task.

H_5: Conservation of substance, continuous quantity, discontinuous quantity, weight, area, volume and density should be attained in the aforementioned order as chronological age increases.

H_6: Several attributes of Vygotsky Blocks performance are functions of mental age.

A. Greater ability to verbalize the principle involved in the correct solution of the Vygotsky Blocks is evidenced by increasing mental age.

B. As mental age increases, more mature types of concepts are used in grouping the Blocks.

C. As mental age increases fewer examiner clues are needed to reach the correct solution to the Blocks.

E. As mental age increases the initial grouping of the Blocks is more quickly formed.

F. As mental age increases, less time is needed to regroup the Blocks following discussion of the principle involved.

G. As mental age increases, fewer errors will occur in the final regrouping.

H. As mental age increases, a greater number of hypotheses are involved in grouping the Blocks.

Chapter IV

Experimental Design

Brief Overview

Each subject was individually administered the Vygotsky Blocks and several Piagetian problems in a small private room which was relatively free from distractions. Responses were recorded by both an audio tape machine and examiner notation. The taped material was later typed out to provide a permanent record of each exact answer. All subject testing, scoring, and initial classification was done by the experimenter, but in addition the Vygotsky material was classified into developmental stages by two independent raters. Computer programs for tabulating frequencies and group means, correlations, analysis of variance, t tests, and step-wise analysis were utilized to analyze obtained data.

The Population

The population investigated by this study was assumed to be normal western Canadian children between four and sixteen years of age.

The Sample

Four male and four female children at each successive

chronological age between four and sixteen years inclusive were selected for study, yielding a total sample of 104 subjects. In order to best select those children who were most truly representative of their age level in typical development, only those who fell within the average range of intellectual ability on either the Stanford-Binet or the Wechsler Intelligence Scale for Children were considered as possible subjects. On the Wechsler test both verbal and performance I. Q.'s in the average range were required, and children whose scores on these sections were more than 15 points discrepant were eliminated from the sample. In addition, the chosen subjects were all in the appropriate school grade for their chronological age. None had either failed or been accelerated through any grades. Children whose records were suggestive of possible organic brain damage or emotional difficulties were not included in the sample. The experimenter also excluded any child who displayed atypical behavior in the testing situation.

The criteria for sample selection were determined on the basis of both face validity and prior research findings. Performance on both Piaget's and Vygotsky's tasks has been found to be readily influenced by emotional and personality factors (Hanfmann and Kasanin, 1937, 1942; Rappaport, 1941, 1942; Des Lauriers and Halpern, 1947; Fosberg, 1947; Semenoff and Laird, 1952; Goldschmid, 1967, 1968; Rappaport, Gill, and Schafer, 1968), and neurological impairment is of

consequence on the Vygotsky Blocks (Hanfmann and Kasanin, 1937, 1942; Rappaport, 1941, 1942; Rappaport, Gill and Schafer, 1968). Rather suprisingly, the effects of organicity on Piagetian tasks does not seem to have been explored. Educational experience has some effect on Vygotsky scores (Hanfmann and Kasanin, 1937, 1942; Rapaport, 1941, 1942; Aldrich, 1944; Norman, Baker and Doehring, 1950; and Rappaport, Gill and Schafer, 1968) but as was noted in the literature review, schooling is not a crucial concern with regards to Piaget's theory. Intelligence is a highly significant variable for both theories (Hanfmann and Kasanin, 1937; Rapaport 1941; Aldrich, 1944; Elkind, 1961; Rappaport, Gill and Schafer, 1968; Goldschmid, 1967; Inhelder, 1968), thus the decision to use a thorough individual intelligence test rather than a more convenient, but less reliable, group measure.

Wherever possible the attempt was made to obtain subjects who had already been given an individual intelligence test. Unfortunately most children in this category seen by established clinics proved unsuitable for present purposes, because the original reason for the testing was often suspected academic or emotional problems. Thus, the majority of the experimental subjects was drawn from a pool of children individually tested by university students in a graduate practicum course of intellectual assessment. These youngsters were essentially normal

children who were seen for relatively minor reasons such as parental interest, chance acquaintance with the examiner and such - in short, the type of child who does not ordinarily come to the attention of clinical psychologists. All student assessments were closely supervised by qualified practioners and all testing had taken place within two years of the present study; hence no re-administrations were necessary in view of the well established test-retest reliability of the measures involved. These student assessments had the additional advantage of complete reports on the child involved, which aided sample selection greatly. The parents of possible prospects gleaned from the university files were contacted by the examiner, and if they consented to having their child participate, an appointment was arranged. Approximately one half of the sample was obtained in this way.

The remaining fifty-four subjects were located through two sources; the public school system in a small urban centre (Camrose, Alta.) and an extensive preschool assessment project which was being carried out in the city of Edmonton at the time, under the auspices of the local board of health and several city hospitals (the Edmonton Preschool Screening Project). It was necessary to give the public school children the Wechsler Intelligence Scale and to consult their cumulative school records to select suitable candidates for the experiment. These children were

tested in school and parental consent obtained by letter. The preschoolers had already had the Stanford-Binet intelligence test during their initial screening; thus, helpful reports were also available. As with the university sample, these parents were contacted by telephone, and appointments arranged.

<u>The Testing Situation</u>

All testing took place in a small quiet room designed specifically for assessment. Each subject was seen alone, and at no time was parental observation permitted. The room contained only the necessary furniture and the test materials (including the tape recorder, which was in full view). The rooms used were usually windowless and all distracting material was removed from the walls. Subjects were always asked for their permission to use the tape recorder, although none ever objected. Testing time varied between 1/2 hour and 1 1/2 hours depending on the age and work habits of the subject. All children were permitted to work entirely at their own speed without interference or suggestion. If a subject changed his mind about participation or expressed a desire to terminate, the session was immediately ended and that subject withdrawn from the sample. Each child was seen only once, with the exception of those who were also given an intelligence test. In this case two separate sessions were necessary. The general purpose of the experiment was of course explained to

parents upon initial contact, but specific details of the tasks involved were not revealed until after the child had been seen, to prevent preconceived prejudices on the part of the subject. Following the experimental session, however, all parental queries were fully discussed.

Task Selection

Vygotsky's entire theory of cognitive development is based solely on performance on his Blocks Test, but there is no comparably comprehensive measure in Piaget's scheme, as he prefers to assess cognitive level on the basis of a number of less inclusive tasks. Thus it was necessary to select Piagetian problems for use in the present study that could be considered genuinely representative of Piaget's total developmental model. It was also deemed desirable to choose tasks that could be administered in a relatively short time with a minimum of equipment, and scored by both quantitative and qualitative methods to permit maximal comparability with the Vygotsky measure. Only Piaget's conservation problems met all these criteria admirably, as well as having the additional advantage of a substantial body of independent research with which to compare obtained findings.

Conservation tasks were chosen as the best type of measure of Piaget's stages primarily because the conservation process is considered by Piaget to be a "necessary condition of all rational activity" (1965, p.

3). He believes the construction of logical operations "may be observed in a singularly clear way through evolution of notions of conservation" and notes that "the psychological sign of the presence of an operational system is in fact the conservation of the whole independent of the transformation its various parts undergo" (1946, p. 401). These statements clearly indicate that performance on conservation tasks reliably distinguishes between pre-operational and concrete operational thought. But what of the final and most vital period of formal operations?

As has been previously noted, there are several different types of conservation described by Piaget (quantity, length, number, volume etc.) which are characteristically achieved by the child at ages varying from six years to early adolescence. Obviously some of these skills are attained at ages well beyond the range postulated by Piaget as encompassing the sub-period of concrete operations, which immediately suggests formal operational functioning. This aspect of conservation performance is discussed at length by Piaget and Inhelder in their 1958 book _The Growth of Logical Thinking from Childhood to Adolescence_, in which they conclude that conservation problems are of two types, "simple" or concrete operational, and "complex" or formal operational. All conservation problems involve two types of reversibility of thought; simple inversion negation, and reciprocity (which

involves recognition of compensatory changes in two related stimuli), but the simple conservations require only sequential application of these reversibilities whereas complex problems necessitate simultaneous use of both types. Thus Piaget considers conservations of quantity, length, number, and substance and area to be in the concrete sphere, whereas volume, density, momentum and rectilinear motion conservations are at the formal level. An excellent summary of Piaget's position regarding formal conservations is available in the publications of Brainerd (1970, 1971) and Brainerd and Allen (1971a, b).

In a discussion of conservation in terms of Piaget's overall developmental theory Inhelder et. al. describe formal operations as "characterized by hypothetico-deductive strategy and the potential for utilizing all possible transformations of relations" (1966, p. 160). This suggests that the truly formal operational thinker should be able to successfully perform all types of conservation problems.

Consideration of both theoretical and practical aspects resulted in the selection of seven conservation problems for use in this investigation substance, continuous quantity, discontinuous quantity, weight and area at the concrete level; volume and density at the formal. In addition one Piagetian verbal reasoning problem was included, as it afforded very quick assessment of formal

operational cognitive capacity. The Vygotsky Blocks were always administered first owing to the length of the task, and the Piagetian problems were arranged in approximate order of ascending difficulty (as quoted above). The verbal question concluded the battery.

Instruments

The Vygotsky Blocks

Materials: The Vygotsky Blocks have been described by Hanfmann and Kasanin as follows -- "The experimental material consists of 22 wooden blocks varying in color, shape, height and size. There are five different colors: red, blue, yellow, green and white; six different shapes: circles, squares, triangles, trapezoids, hexagons and half-circles; two heights: tall blocks and flat blocks (3/4 in. and 5/16 in. respectively); and two sizes of top (or bottom) area: large and small blocks (the area of top surface approximately 1 1/3 sq. in. and 3/5 sq. in. respectively). On the under side of each figure which is not seen by the subject, is written one of the following four nonsense words: lag, bik, mur, cev. Regardless of color and shape, lag is written on all large tall figures, bik on all large flat figures, mur on the small tall ones, and cev on the small flat ones " (1937, p. 521).

Administration: The administrative procedure devised by Meece and Rosenblum (1965) was adapted for use in

the present study, as it permits unlimited time for the subject to devise his initial grouping, an important consideration in view of Vygotsky's developmental theory. This method is a slight modification of Hanfmann and Kasanin's administration for children, which was based on Vygotsky's original Russian writings. The subject is instructed:

> There are four different kinds of blocks here. Each kind has a name. This kind of block, for instance (turning up the triangular mur), is called mur. Your task is to find these four kinds. You might start out by picking out all the blocks that you think might belong to this kind, mur. Remember that there are just four kinds of blocks.

After completion of the first grouping, the subject is asked:

> Can you tell me why you put those there?

The block which is most in error is turned over and the subject told:

> This one has a different name; it is a block of a different kind, a bik. We shall put it here. I can turn only one block at a time; the rest may be right or wrong, or some might be right and some wrong. You must decide for yourself if they should be left or taken away. I am showing you one mistake. The rest may be correct or they may not.

If the subject waits for further instructions, the examiner says:

> Try again picking out all the murs. Or you can try the (kind turned up) or any other kind you like.

A new clue is turned up by the examiner every five minutes for the next 30 minutes thereafter. The first three samples turned over should represent each kind of block. The subject is then informed:

> Now you have a sample of each kind. All of the rest belong to one of these four kinds. You must put each block where it belongs.

All blocks turned over remain in this position, with names exposed. After all blocks are correctly grouped, those with names still hidden are turned over. The subject is then asked:

> How could you tell the blocks apart if you couldn't see the names?
> In what way are all the <u>lags</u> the same?
> Why do they have the same name?
> How are all the <u>lags</u> different from all the <u>cevs</u>? Why do they have different names?

If the subject has not mentioned the size difference to this point, it is pointed out by the examiner, and the subject helped to find an adequate formulation of the principle. Following this, previously failed questions are readministered. If the subject fails again he is helped to find the correct answers and made to repeat the definition of each group in terms of double dichotomy (lag - large and tall, bik - flat and large, mur - tall and small, cev - flat and small).

The blocks are then turned over to hide the names and reshuffled. The subject is told:

> Now that you know what the different

> kinds of blocks are, see if you can put them back again into their four groups.

This completes the standard administration; however, with children special situations often arise. These are to be dealt with as follows:

If S asks about the number of blocks in a group, he is told that they need not be equal.

If he asks whether the classification is logical and consistent, he is assured that it is.

If S is worried about "catches" or "foul play" he is reassured that this is not so. If S asks if there is a time limit, he is told there is none.

If S begins to turn the blocks over to solve the problem, he is told "The names are written on the bottom, but you must not turn the blocks over to read them". If he responds "Then how can I tell?" He is told "Yes, but the names stand for something. There is some reason why the blocks have the same name, and you have to find it out." After several purely random groupings or lengthy inactivity, the subject may also be informed:

> The blocks have the same name because they are the same in some way. You must put together the blocks that are the same in some way.

If S asks if some specific manner of classification is correct he is told:

> It is up to you to find out which blocks belong together--I am not supposed to tell you; it might be (color, shape, etc.) or it might be something else.

If the S does not begin work after initial instructions are complete, he is told:

> When you have picked out all the blocks you think might be mur, I shall turn one up, and you will see whether you were right or not.

If S asks about a characteristic, is given the above reply, and refuses to try without knowing if he is right or wrong, he is told to try the element he mentioned.

If S hides the names of the overturned clues, or groups them all together, he is cautioned against doing so.

The Piagetian Tasks

All experimental procedures were taken from Goldschmid (1967) with the exception of the conservation of density (Brainerd and Allen, 1971b), the check on the conservation of continuous quantity (Piaget, 1967b) and the formal operations question (Piaget, 1961). These conservation methods were chosen because they conformed most closely to Piaget's original formulations, but had the additional advantage of a clear-cut numerical scoring system which yielded data amenable to statistical manipulation.

Conservation of Substance (Mass)

Materials: 2 plasticine balls (approximately 6 inches in circumference) of different colors but the same size, shape, and height.

Administration The balls are placed before the subject with the query: "Do both balls have the same amount of

plasticine, is there as much plasticine in this ball as in this one?" If the subject doubts the equality of the balls he is told to "make them the same."

The examiner then transforms one of the balls into a hot dog shape and asks the subject, "Is there as much plasticine in the ball as in the hot dog." After S responds E. queries, "Why is that?" The hot dog is then returned to the ball shape and the procedure is repeated with transformations into a pancake shape, and 10 little balls of approximately the same size.

Conservation of Continuous Quantities

Materials: two identical beakers (250 millilitres, 9 inch circumference), tall thin glass (250 millilitres, 5 inch circumference), a flat extended glass (250 millilitres, 9 1/2 inch diameter), and five small glasses (50 millilitres, 5 1/2 inch circumference), water, large plastic pitcher.

Administration: the two identical beakers are filled with an equal amount of water (150 millilitres) and the child asked the identity question as above. After the child is satisfied as to equality, water from one pitcher is successively poured into containers of the various shapes cited above. Following each transformation the subject is asked the conservation question, "Is there as much water in this glass as in this glass (or glasses)? Why is that?"

After responding to all three transformations the

child is again presented with the tall narrow glass and the short wide one. He is given the pitcher of water and told "Pour the same amount of water into each of these". Piaget (1967) considers this pouring task a quick method of discriminating between the true and "pseudo" conservers.

Conservation of Discontinuous Quantity

Materials: as for continuous quantity problem, substituting corn grains for water.

Administration: as for continuous quantity section, excluding Piaget's "pouring" check.

Conservation of Weight

Materials: as for mass problem.

Administration: as for the mass section but the question is phrased "Do they both weigh the same, do they both have the same amount of weight? Or is one heavier?"

Conservation of Area

Materials: 2 identical green cardboards (10 X 15 inches), 2 cows (1 in. tall, 1 1/2 inches long), 28 cubes (1" X 1" X 1").

Administration: The examiner begins: "Let's imagine that these two sheets of paper are two fields of grass. We'll put a cow in each field. (Place in centre of sheets.) Now, does each cow have as much to eat as the other?" If S doubts, he may measure the sheets. E continues: "Let's imagine this block is a barn. We'll put the barn on this

field. Now will each cow have the same amount to eat? Suppose we put a barn on this other field. Now will each cow have the same amount to eat?"

One, four and six barns are added successively to each field. On one field they are arranged in neat rows touching each other, on the other they are spread out haphazardly. After each addition the child is asked if the cows have the same amount to eat. When all the barns are added, the subject is asked, "Why is that?"

<u>Conservation of Volume</u>

<u>Materials:</u> as in mass problem.

<u>Administration:</u> as in mass problem, but the question is phrased: "Do they both take up the same amount of space, do they both take up as much room?" (Originally from Elkind's 1961 study.)

<u>Conservation of Density</u>

<u>Materials:</u> as in mass problem.

<u>Administration:</u> S is shown a plasticine ball and a beaker full of water and asked:

> "Will this ball float or stay on top of the water or will it sink to the bottom?"

Following the answer, its sinking is demonstrated. The ball is flattened into a "raft" and S asked (in random order)

> "Do you think this will float?" "Why?"
> "Do you think this will sink?" "Why?"

The raft is then returned to 25% cf its former size, and S is questioned again. A final transformation is made so that the piece is about half the size of a dime and the question repeated.

Finally S is asked:

> "Do you think that we would ever get a piece of plasticine small enough so that it would float (or stay on top of the water)?" (from Brainerd and Allen, 1971).

Formal Operations Question

S is asked:

> "Edith is taller than Susan, Edith is shorter than Lilly; who is the shortest of the three?"

From Piaget (1961) substituting taller and shorter for fairer and darker as preliminary testing revealed the "fairness" concept was confusing to youngest subjects. This question involves verbal seriation, thus demonstrates propositional formal reasoning, as opposed to concrete.

Validity and Reliability of the Instruments

All subsequent research on all measures in question here supports their validity as indicators of level of cognitive sophistication or conceptual development, but the nature of the problems renders reliability very difficult to establish. It is cbvicusly impossible to split the tests into comparable halves, and as the tests reflect developmental level it is to be expected that the responses

of the individual subject will alter over time. Alternate forms do nct exist fcr the Piagetian problems, as even slight change of material or method may alter the difficulty of the item somewhat (Goldschmid, 1967). However, a parallel form of the Vygotsky Blocks devised be Semeonoff and Laird (1952) yielded "such consistency of approach" to those on the original that this type of reliability may be considered established.

Scoring of the Vygotsky Blocks

The quantitative scoring method devised by Meece and Rosenblum was employed, with some minor modifications necessitated by the greater range of ages included in the present study (1965, p. 1S7,198). This included nine measures as follows:

1. Time to the first tentative grouping: The time in seconds which lapsed from the child's initial view of the blocks to the point where blocks were first grouped to his/her verbalized satisfaction.

2. Basis for first grouping: A statement of S's first tentative hypothesis for classification. As the two most obvious characteristics of the blocks are their form and color, these were used as the bases for initial groupings. For quantitative purposes form was assigned a value of "1" and color of "2".

Inability to state a reason for initial grouping was scored "0".

3. Total time to the solution of task: A measure reported in minutes and calculated from S's first view of the blocks until grouped correctly or the final block needs to be turned over. This is a slight modification of the Hanfmann-Kasanin method which begins timing right after the instructions are given.

4. Number of clues given by E: A clue in this situation is a block turned up so that its name can be seen. One clue was given as a sample at the beginning of the task, and others were provided after each grouping, or the lapse of a period of time with no tentative grouping evidenced by S.

5. Number of hypotheses attempted: The total times S was able to provide a basis for grouping the blocks as he/she did. To encourage such hypothesizing and discourage random placement without hypotheses, S was asked to state the basis for his/her groupings after each move.

6. Number of different types of hypotheses attempted: The total number of different verbalized reasons provided by S for grouping the blocks as he/she did (e.g., color, form,

height).

This sixth scoring criterion was found very difficult to put into practice as subject responses contained a very wide range of subtely varying reasoning. Since no further explanation of exact categories used by Meece and Rosenblum was available, the differentiations used by Penny in his administration of the Vygotsky Blocks were employed (Penny, 1951 p. 71, 72). These include color, form, height, width, surface area (as evidenced by reasoning such as "the bigness of the top" or matching two blocks and referring to the difference in top surface) volume, patterns (fitting the blocks together to make towers or designs). They also included poor forms (matching a triangle to a trapezoid because one is an incomplete version of the other, or use of concepts such as number of sides, or angularity); equality, (blocks placed together because of equality of numbers in each group etc.) of numbers colors poor forms, etc., mixed groups of colors, numbers, forms etc.; and primed categories which are used when the subject differentiates groups on the basis of minute variations or uses far fetched rationalizations. As an example, if a subject placed all the white blocks together and said "I put them together because they are all the same color", this was considered a color response. If he then made four groups consisting of one white, one green, one yellow, and one blue block and said "They all have one of each color in them", he was given

credit for a mixed colcrs respcnse. If he then made groups with three green blccks in each and said "They each have three greens," this was scored an equality of color response. If the subject then put together red, white and blue blocks with the reasoning "They go together because they make a union jack," a primed color response was recorded. Thus, in this illustration four color related responses were given, but they were considered four different types of hypotheses for purposes of this scoring criterion.

7. Level of verbalization: A rating of "1" was given S if the subject could state the concept involved in the grouping task correctly; a score of "2" if the concept was verbalized after guidance from E; and "3" if the S was unable to state it acceptably.

Here, too, a slight modification of Meece and Rosenblum's criterion was required. Many subjects' explanations of the principle underlying the Vygotsky Blccks referred to "size." In this case it was difficult to ascertain whether the child had truly understood the correct concept of double dichotomy (height and width). Requests for additicnal explanation usually resulted in a slight variation in wording of the same size concept, thus it was necessary to score level of verbalization twice--once on the bases of comprehension of the size concept, and once on the

double dichotomy principle. The numerical rating was identical in each case; one point for a spontaneous explanation and two points for an assisted response. Subjects who replied in terms of double dichotomy only were assumed to possess the size concept as well and were scored accordingly.

8. Time for final regrouping: The time, recorded in seconds, taken to classify the blocks again after having verbalized the concept successfully or having been told the concept by E.

9. Number of errors in the final re-grouping: The number of wrong placements in the reclassification of the blocks during the second grouping procedure.

In addition to the aforementioned quantitative measures, all subject responses were also qualitatively categorized on the basis of Vygotsky's developmental stages by the experimenter and two independent raters. The raters were undergraduate university students with some experience in the area of developmental psychology, but who were unfamiliar with Vygotsky's theories prior to the experiment. They were given copies of Vygotsky's book Thought and Language and their attention was directed particularly to the section describing levels of performance on the Blocks (1962, p. 52-81). On the basis of the knowledge gained

from this exposure, the raters assigned each verbatim copy of the subject's responses to the appropriate cognitive stage.

Each rating was then transformed to a numerical scale for purposes of statistical manipulation. One point was assigned to the least sophisticated substage in Vygotsky's system, two for the next highest and so on.

One other qualitative measure was used, as each individual grouping by each subindividual subject rated in terms of the most frequently occurring level. This scoring procedure was devised by Stones and Heslop, (1968) and was carried out by the experimenter alone.

Scoring the Piagetian Tasks

The quantitative scoring method of Goldschmid (1967) was utilized for all conservation problems in the present study. This procedure assigns two scores for each individual transformation on all tasks:

1. Conservation score: Two points were given for each correct response on the comparative portion of the problem. Incorrect answers received zero points.

2. Explanation score: Two points were awarded for an abstract, conceptual response (i.e. "nothing was added to or subtracted from" the substance of the object); one point was scored when the

child offered a "perceptual" answer (i. e. "It looks like they are the same"); and no points were given for "magical" answers (i. e. "My teacher told me so") or when no explanation at all was forthcoming.

In the case of the density problems, many children referred to the weight of the plasticine in their explanations but could not supply further information when queried. Since it was difficult to judge their verbalization, two points were given for each answer if the child recognized that all three transformations sank in the water "because they are heavy" or "because they are heavier than water". If the subject thought only one or two transformations sank because of weight, it was apparent that he did not fully understand the concept involved; thus a score of one was awarded for each such response.

These scores were added together for all parts of each task to yield a single task total score. Three overall totals were then computed;

TS: the total of all conservation scores

TE: the total of all explanation scores

TT: the sum of TS and TE

Each of these measures was further divided into subtotal scores for the concrete operations problems and the formal operations tasks, resulting in TS(c), TE(c), TT(c), TS(f), TE(f) and TT(f). Scores on the substance, quantity, weight

and area conservation problems were included in the concrete section, and conservation of volume and density in the formal score.

Also, Piaget's verbal seriation question earned two points for a correct answer, which was added to the formal conservation scores. Zero points were given for an erroneous response. No explanation of this question was required.

Each conservation response for each subject was then qualitatively judged on the basis of Piaget's descriptions of conservation attainment and overall developmental stage theory (1957, 1968 etc.), and the total number of concrete and formal conservations computed for each child. Those subjects who conserved on less than three concrete tasks (of five) and who failed two or more of the formal problems (of three) were judged to be at the pre-operational level of cognitive development. Children who conserved on three or more of the concrete tasks, but less than two in the formal realm were considered operational thinkers, and those who scored 4 or 5 on the concrete as well as 2 or more on the formal were rated at the formal operational stage as was the case with the numerical scoring. Each response was evaluated twice--once considering the comparative response only, and once considering the explanation given for the phenomenon as well.

The overall performance of the younger subjects (aged

4-11 years) on each conservation task was then classified according to categories devised by Little (1972) to correspond to Piaget and Inhelder's (1964) three stages of conservation acquisition. These are:

(1) Random actions; seems to lack comprehension of basic concepts of "more" or "the same".

(2) Understands basic concepts but makes global undifferentiated responses.

(3) Negative, "silly" and tangential behaviour.

(4) Perceptual attribute and unable to explain choice.

(5) Perceptual attribute and explains reason for choice.

(6) Makes comparisons using fingers or pencils to "measure".

(7) Changed answer when queried, unable to explain why.

(8) Changed answer on query and can give reason.

(9) "Knew" correct answer on first question and unable to give reason.

(10) "Knew" correct answer on first question and could give explanation.

(Little, 1972, p. 1028)

Little asserts that categories 1,2, and 3 are indicative of Piaget's first conservation level; categories 4-9 inclusive correspond to level 2 as they show understanding of the task

but intuitive reasoning and/or use of single dimension comparisons; and category 10 assumes the third and final level of concrete logic, as the child is either able to explain or demonstrate his choice.

Finally, all subjects' explanations of conservation were classified in the manner of Papalia (1972) and Brainerd (1971) into the following categories:

Papalia's System (1972, p. 233)

(1) Inadequate rationale: Based upon the immediate perceptual features of the tasks or irrelevant statements.

(2) Reversibility: "You can put clay back into a ball" etc.

(3) Statement of the operation performed: "We just flattened the clay so it is just the same" etc.

(4) Addition-subtraction: "You didn't add any or take any away".

(5) Compensatory-relations-proportionality: "That is longer and skinnier, but this is shorter and fatter" etc.

(6) Sameness of materials used: "It is still the same clay" etc.

(7) Reference to the previous state of equality between stimuli: "We had the same amount before, so we still have the same now".

(8) Counting: "There were about 50 ml. before, so there is still the same now" etc.

Brainerd's System (1971, p. 472)

(1) Inversion reversibility: the fact that perceptual deformations could always be reversed.

(2) Reciprocity reversibility: the fact that changes in certain dimensions were compensated by changes in related dimensions. Equivalence explanations ("They are just the same") also fell in this category.

(3) Addition-subtraction: the fact that nothing was added to or removed from the stimuli. (from Brainerd and Brainerd, 1972).

(4) The fourth category is conceptually irrelevant explanations which although they are not based on simple perceptual features of the stimuli, nonetheless are irrelevant to why conservation actually obtains. For example, "It is the weight that makes it so," does not explain either volume or density conservation.

(5) Perceptually irrelevant: mention of deceptive perceptual features.

(6) Don't know: no response

Both of these classification procedures were used because Papalia's seemed particularly relevant to the concrete level conservation problems, and Brainerd's encompassed more of the formal operational concepts. Thus, the three qualitative classifications employed corresponded roughly to Piaget's major developmental stages; Little's covered the pre-operational to concrete-operational period; Papalia's the operational to the formal logic stage, and Brainerd's

the formal level itself.

Statistical Analysis

Initially the means and standard deviations of all quantitative scores for both the Vygotsky and the Piagetian data were computed by each age and sex group, as well as the entire sample. A t test was then carried out on the male vs the female scores in each task area to ascertain if any significant differences existed between the responses of the sexes, thus testing H_4. The scores for the whole sample were used in these tests as opposed to calculating separate contrasts for each age level, as the number of subjects of each sex at each age was deemed too small to yield meaningful statistics (N=4).

No significant differences were found between male and female performance on any task (see Chapter V) so the scores of both sexes were combined for all subsequent analyses. This yielded a group of eight subjects per age level, thus it was considered desirable to test for significance of difference in performance between age groups for each task in the battery. Testing the fine distinctions in responses between subsequent years for H_3 provided valuable information on the manner in which concepts were attained, which is of prime importance to any consideration of developmental stage theories, such as the present investigation.

Analysis of variance was chosen as the best method of comparing age levels in spite of the fact that some of the data were not of the interval or ratio type. In fact, a parametric measure was specifically selected because "that test will be more powerful than any other in rejecting H_0 when it is false" (Siegel, 1956, p. 19), thus it affords the greatest accuracy of prediction. Use of analysis of variance assumes that the variables in question are normally distributed in the population from which the sample is drawn, that population variances are equal, and that the effects of the various factors on the total variation are additive (Ferguson, 1966; Guilford, 1965). In the present case the first assumption is clearly not met, and the others are only roughly satisfied. However, Ferguson assures that this is usually the case with most real data, and suggests that analysis of variance has the advantage that "reasonable departures from the assumptions of normality and homogeneity may occur without seriously affecting the validity of the inferences drawn from the data" (1966, p. 295). Departures from the above assumptions may be somewhat compensated for by employing a more rigorous criterion for rejection of the null hypothesis, thus the Scheffe method contrast was deemed most suitable for present purposes. This test has the highest probability of Type I error, so is likely to yield fewest significant differences. For this reason a lower level of significance is often used in conjunction with the

Scheffe, however this procedure was not considered for the present study because utmost rigor was required. Thus the traditional .05 and .01 levels were used for the analysis of variance and on all other statistics used in this investigation.

Analysis of variance was the method of choice for comparing performance at various age levels, but it could not be used on several variables because there was no variance at some ages. This tended to occur particularly on the Piagetian tasks, where all of the youngest subjects would fail the problem, and all of the oldest ones would pass. Even one instance of zero variance would render the entire matrix for analysis of variance invalid, as each age level is compared with every other. In this case, individual t tests were carried out just between adjacent age levels on the variable in question, using only those ages where variance occurred. Although a t test is actually one specific case of analysis of variance, it is not nearly so robust, especially in comparison to the rigorous Scheffe contrast. T tests are also less independent when several are employed on the same variable, so obtained results must be interpreted with more caution.

Homogeneity of variance was always tested for each variable, using the Hartley Test in the case of analysis of variance. This test is described by Winer as "sufficiently sensitive" for the robust F test (1962, p. 94). Where

variances were not homogenious, analysis of variance was abandoned, but in the case of the t test, a modified statistic (the Welch t prime adjustment) was used.

Analysis of variance and/or t tests have been employed by other investigators on similar data (Brainerd, 1971; Goldschmid, 1967; and Uzigris, 1964). Uzigris acknowledges that her data do not meet all assumptions for analysis of variance, but concludes that this fact does not invalidate the procedure.

Comparison of the Piagetian data with the Vygotsky results (H_1 and the virtual raison d'etre of the study) was unfortunately complicated by the fact that the Vygotsky scores were not additive and thus yielded no total scores. As well, many different types of measures were involved (time in seconds, number of occurrences etc.). Hence the Vygotsky variables were not easily contrasted either to the Piagetian data or to each other. As a result, Pearsonian correlations emerged as the most suitable measures for comparing the various aspects of all cognitive tasks. The present data meet all assumptions required for use of Pearson r; as the scores are quantitative, the trend of the relationship between all variables is linear (because the scores on all tasks are assumed to increase as a function of age), and the distributions of the variables need not be normal (Ferguson, 1966; Guilford, 1965). Pearson r's were thus computed between all quantitative scores, all age

levels and the raters' judgements of the subject's overall Vygotsky performance. These judgements were transformed to a corresponding numerical system ranging from a score of one for the lowest level, to a score of fourteen for the highest. The resulting wealth of correlational data yielded information relevant to H_1, H_2, and H_6, as well as a measure of inter-rater reliability. Probabilities that r=0 were also computed, and the usual significance levels applied. Similar correlational procedures have been carried out by other investigators in the area (Meece and Rosenblum, 1965; Goldschmid, 1967).

A step-wise regression analysis was carried out separately on the Piagetian and the Vygotsky data to determine which measures best predicted mental age in each system. In the case of the Piaget results the total scores for each task were used, and the ten scoring variables for the Vygotsky Blocks served as suitable measures. A similar type of analysis (the Wherry-Doolittle Method of test selection) was used by Meece and Rosenblum (1965). Step-wise analysis was judged superior to multiple regression for present purposes because it has the advantage of considering all variables in question after each stage of analysis, rather than eliminating each successive variance as it is computed.

Scalogram analysis was applied to Piagetian conservation data by Uzigris (1964) for purposes of obtaining an index of the sequential attainment of various types of conservation; thus, this technique seemed an ideal method of exploring H_2, H_5 and developmental scale theory in general. As the sample size exceeded the minimum requirement of N=100, and the Piagetian results could be scored dichotomously by assigning a value of one for a success in a particular task and a value of zero for a failure, the assumptions of scalogram analysis were readily met. The Goodenough method of Guttman's Scalogram Analysis was employed on two criteria of Piagetian success, one considering the subject's explanation of the conservation phenomenon, and one considering only the subject's initial judgements. Responses to the Formal Operations Question were included in the matrix as well.

The level of difficulty of the various Piagetian tasks (H_5) was further investigated by normalizing the distribution of scores for each area of conservation. A t transformation was performed on all raw scores for each task, and the resulting distributions ranked in order of their transformed means. Goldschmid (1967) also used this method of comparison.

All of the above methods of analysis were performed with the aid of computing services available at the University of Alberta using programs documented by the

Division of Educational Research Services. In addition, several measures of frequency distribution were changed to percentages by hand calculator for purposes of constructing more meaningful tables of results. For the Piaget data, the percentage of subjects passing each task at each age level was ascertained both in terms of conservation or judgement scores, and explanation scores. A subject was credited with success on a given task if he replied correctly to at least two out of three subtests, or at least three out of four, if four parts were involved. Judgement and explanation scores were considered independently. The percentage of subjects at each age level falling at each Piagetian stage was also determined for both explanation and judgement scores, and the percentage of subjects presenting various types of explanations for conservation was computed in the manner of Brainerd (1971), Papalia (1972), and Little (1972). These frequency computations yielded information relevant to H_2 and H_5.

The percentage of responses to the Vygotsky Blocks falling at each Vygotsky stage was found by placing each grouping of every subject in the appropriate level, as Stones and Heslop (1968) did. The percentage of subjects at each age level with no errors in the final regrouping of the Blocks, the percentage who were able to verbalize the concept following examiner assistance, and the percentage who spontaneously stated the concept involved was also

ascertained, to permit ccmparison with Meece and Rosenblum's (1965) results. This informaticn provided additional insight into H_6.

Chapter V

Results and Discussion

Results Obtained From the Vygotsky Investigation

A summary of the t tests carried out between the males and females in the sample is found in Table 1, with the corresponding F ratios reported in Table 2. The F scores are all indicative of homogeneity of variance, thus the t test may be considered to be appropriately applied here, as the most crucial assumption underlying use of the test is satisfied. No significant sex differences emerged using either a one or a two tailed test, so the results of both groups were combined for all subsequent analyses.

The intercorrelations among all the Vygotsky scoring variables are contained in Table 3, as well as the correlations between the scoring variables and age. Of the correlations computed, 34 are significant at the .01 level and 7 are significant at the .05 level. All scoring variables correlate highly significantly with age, with the exception of "Number of Hypotheses Mentioned." This variable also correlates significantly with the fewest number of other scoring dimensions, as it does not appear to be related to the time taken to form the first grouping, the level of verbalization achieved, the time to regroup the blocks, or the number of errors in the final regrouping.

TABLE 1

T-TESTS BETWEEN MALES AND FEMALES ON THE VYGOTSKY VARIABLES

Variable	Mean - Males	Mean - Females	Standard Deviation - Males	Standard Deviation - Females	DF	T	P-One Tail	P-Two Tail
Time to First Grouping	83.62	84.73	41.58	51.92	102	-0.121	0.452	0.904
Basis of First Grouping	2.56	2.69	0.80	0.70	102	-0.911	0.182	0.364
Number of Examiner Clues	14.58	15.21	5.87	6.33	102	-0.530	0.299	0.597
Total Time	21.08	22.46	8.58	9.58	102	-0.776	0.220	0.440
Hypotheses Mentioned	14.81	15.31	8.34	8.85	102	-0.296	0.384	0.767
Number of Different Hypotheses	6.27	5.69	3.09	2.72	102	1.011	0.157	0.314
Level of Verbalization (re: size)	1.38	1.50	0.66	0.80	102	-0.799	0.213	0.426
Level of Verbalization (re: double dichotomy)	1.88	1.83	0.76	0.76	102	0.388	0.350	0.699
Time for Final Regrouping	81.75	73.04	83.93	67.56	102	0.583	0.281	0.561
Number of Errors in Regrouping	3.48	3.04	6.14	6.77	102	0.349	0.364	0.728

TABLE 2

F-TEST OF DIFFERENCE BETWEEN MALE AND FEMALE VARIANCES ON THE VYGOTSKY VARIABLES

Variable	Variance - Males	Variance - Females	DF	F	P-Non-Directional
Time to First Grouping	1729.18	2695.77	51	1.559	0.116
Basis of First Grouping	0.64	0.49	51	1.309	0.339
Number of Examiner Clues	34.41	40.13	51	1.166	0.585
Total Time	73.56	91.82	51	1.248	0.431
Hypotheses Mentioned	69.57	78.33	51	1.126	0.673
Number of Different Hypotheses	9.53	7.39	51	1.289	0.367
Level of Verbalization (re: size)	0.44	0.65	51	1.479	0.165
Level of Verbalization (re: double dichotomy)	0.57	0.58	51	1.005	0.987
Time for Final Regrouping	7044.98	4564.86	51	1.543	0.125
Number of Errors in Regrouping	37.67	45.84	51	1.217	0.486

TABLE 3

INTERCORRELATIONS AMONG VYGOTSKY VARIABLES

Variable	Age	Total Time	Time to 1st Grouping	Verbalization (size) (si	Verbalization (double dichotomy)	Final Time	Final Errors	Number of Hypotheses	Number of Different Hypotheses	Basis of First Grouping	Number of Clues
Age		-.391**	-.284**	-.728**	-.707**	-.492**	-.619**	-.023	.442**	.360**	-.649**
Total Time			.141	.394**	.468**	.362**	.305**	.457**	.081	.004	.722**
Time to First Grouping				.340**	.214*	.227*	.239*	-.070	-.176	-.252**	.240*
Verbalization (re: size)					.749**	.470**	.757**	-.081	-.442**	-.358**	.560**
Verbalization (re: double dichotomy)						.426**	.657**	.065	-.355**	-.378**	.727**
Final Time							.374**	.023	-.212*	-.244*	.347**
Final Errors								-.085	-.409**	-.309**	.438**
Number of Hypotheses									.585**	.206*	.426**
Number of Different Hypotheses										.403**	-.182
Basis of First Grouping											-.235*

*Significant at the .05 level.
**Significant at the .01 level.

The total time taken to solve the blocks did not correlate with either the time or basis of the initial grouping, or with the number of different hypotheses mentioned. This latter variable was also independent of the number of examiner clues and the time to the first grouping.

The strong relationships between age and the scoring variables provide confirmation of all aspects of H_6 excluding section H. Although a greater number of different hypotheses are presented as a function of increasing mental age, the number of hypotheses _per se_ does not change significantly with age. These correlational findings compare favourably with those of Meece and Rosenblum (1965), but the original investigators did not obtain significant results regarding age and number of clues or total time. A general trend in the hypothesized direction did emerge however. Meece and Rosenblum felt that all variables which correlated highly with age, and all those which were relatively independent of other measures should be included in the Vygotsky scoring battery; which seems a reasonable criterion. On this basis, all ten scores emerge as suitable determinants of performance.

As all measures may be appropriately retained in the scoring battery, the next major consideration is determination of which of the ten variables best predicts mental age. Stepwise regression analysis (Table 4) was employed for this purpose. Level of verbalization regarding

TABLE 4

STEP-WISE REGRESSION PREDICTING AGE FROM TEN VYGOTSKY VARIABLES

Variable	F-Value	Probability Level	% of Variance Accounted for	% of Total Variance Accounted for	Standard Error of Predicted Y
Level of Verbalization (re: size)	115.292352	0.000000**	53.058633	53.058633	2.588561
Number of Examiner Clues	21.513187	0.000011**	8.242855	61.301488	2.361931
Number of Different Hypotheses	6.949669	0.009720**	2.514658	63.816146	2.295293
Time for Final Grouping	5.024613	0.027222*	1.747758	65.563904	2.250454
Total Time	2.230525	0.138520	.766339	66.330243	2.236596
Number of Errors in Final Regrouping	1.518185	0.220873	.518858	66.849101	2.230707
Level of Verbalization (re: double dichotomy)	0.407276	0.524876	.140047	66.989148	2.237554
Number of Hypotheses Mentioned	0.066007	0.797800	.022919	67.012069	2.248518
Basis of First Grouping	0.056204	0.813117	.019712	67.031781	2.259771
Time to First Grouping	0.013920	0.906338	.004933	67.036714	2.271718

*Significant at .05 level.
**Significant at .01 level.

size considerations, the number of examiner clues, and the number of different hypotheses mentioned all contributed highly significantly to the total variance, and the time required for the final regrouping predicted at the .05 level. Level of verbalization alone accounted for 53 per cent of the variance, and all four of the significant measures yielded 65 per cent of the total. Meece and Rosenblum also obtained four significant predictors using a slightly different statistical procedure (the Wherry-Doolittle method of test selection). In their analysis as well, level of verbalization emerged as the most important factor, with "Final Time" also contributing significantly.

In the present study Meece and Rosenblum's "Level of Verbalization" criterion was broken up into two parts, as the meaning of the original measure was rather obscure. The major age predictor here was the verbalization of the size principle, with "double dichotomy" making a much less significant contribution. Since the "size" variable corresponds so closely to Meece and Rosenblum's results, it seems probable that this method of scoring most closely resembles the original measure. The time for the first grouping and the basis of same were the remaining important predictors in the earlier study, which is in contrast to present results.

In view of the fact that the present investigation involves a larger number of subjects (104 as opposed to 50

in the Meece and Rosenblum study) and a much greater range of age levels (13 vs 2), these results may be legitimately considered the more accurate assessment of variables predicting mental age. Both investigations do agree strongly that "Level of Verbalization" accounts for the greatest proportion of the variance. Meece and Rosenblum suggest that this finding indicates "development of verbal proficiency is the most important factor in the development of conceptual thinking" (1965, p. 201).

Meece and Rosenblum also consider the two variables which best predict age to be of prime importance in assessing overall level of conceptual thinking. On this basis, they feel ability to state the principle involved in grouping the blocks provides a verbal criterion of success on the Vygotsky task, and ability to regroup the blocks without error provides a performance criterion. The percentages of subjects at each age level in the present study who solved the Vygotsky problem in accordance with each of these criteria are to be found in Tables 5, 6, and 7. Fifty per cent of the 7 and 8 year olds, 87.5% of those aged 9-13, and 100% of the 14 and 15 year olds were able to successfully regroup the blocks. Seventy-five per cent of the 14 and 15 year olds were able to spontaneously state the concept involved in the problem, and 75% of those aged 7-9 were able to verbalize the underlying principle with examiner assistance.

TABLE 5

PERCENTAGE OF SUBJECTS WITH NO ERRORS IN THE FINAL REGROUPING OF THE VYGOTSKY BLOCKS

Age	Males %	Females %	Total %
4 years	0	0	0
5 years	0	0	0
6 years	0	0	0
7 years	50	50	50
8 years	25	75	50
9 years	100	75	87.5
10 years	100	75	87.5
11 years	75	100	87.5
12 years	100	75	87.5
13 years	75	100	87.5
14 years	100	100	100
15 years	100	100	100
16 years	75	100	87.5

TABLE 6

PERCENTAGE OF SUBJECTS WHO SPONTANEOUSLY STATED THE CONCEPT INVOLVED IN THE SOLUTION OF THE BLOCKS

Age	Males %	Females %	Total %
4 years	0	0	0
5 years	0	0	0
6 years	0	0	0
7 years	0	25	12.5
8 years	25	0	12.5
9 years	25	25	25
10 years	50	25	37.5
11 years	75	25	50
12 years	25	50	37.5
13 years	50	75	62.5
14 years	50	100	75
15 years	75	75	75
16 years	75	25	50

TABLE 7

PERCENTAGE OF SUBJECTS WHO WERE ABLE TO STATE THE CONCEPT INVOLVED IN GROUPING THE BLOCKS FOLLOWING EXAMINER ASSISTANCE

Age	Males %	Females %	Total %
4 years	0	0	0
5 years	0	50	25
6 years	0	25	12.5
7 years	75	75	75
8 years	75	75	75
9 years	75	75	75
10 years	50	75	62.5
11 years	25	75	50
12 years	75	50	62.5
13 years	50	25	37.5
14 years	50	0	0
15 years	25	25	25
16 years	25	75	50

These results are in sharp contrast to those reported in Table 8, which illustrate the percentages of subject responses to the Vygotsky Blocks falling at each major Vygotsky stage. These figures were arrived at by rating each individual subject grouping on the basis of Vygotsky's own descriptions, in the manner of Stones and Heslop (1968). Here only 2.75% of the groupings made by 7 year olds were of the type indicative of the highest level of thought, and the maximum percentage of fully conceptual reasoning was 68.6%, which occurred at 15 years. Present findings seem to be in keeping with those of Stones and Heslop, who found no Phase 3 groupings prior to age 8, with a gradual increase to about 40% at their maximum age of 11 years 6 months. The discrepancies between the success criteria of Meece and Rosenblum and the occurrence of Phase 3 grouping is particularly apparent at the younger age levels, as 75%, 50%, or 12.5% of the 7 year olds "succeeded" on the Vygotsky blocks on the basis of various criteria, yet only 2.75% of their solutions were conceptual. This suggests that performance on these individual scoring variables alone does not necessarily reflect conceptual thinking, even if they are the best predictors in the battery. Stones (1970) notes that ability to correctly regroup the blocks is more a test of short-term memory than of actual comprehension of the nature of the task. It could also be argued that memory is a major factor involved in stating the concept with examiner

TABLE 8

PERCENTAGE OF SUBJECT RESPONSES TO THE VYGOTSKY BLOCKS FALLING AT EACH MAJOR VYGOTSKY STAGE

Age	Phase of Syncretic Images %	Phase of Complexes %	Phase of Conceptual Thinking %
4 years	46.125	53.875	
5 years	46.50	53.50	
6 years	50.0	50.0	
7 years	10.625	86.625	2.75
8 years	26.625	65.125	8.250
9 years	1.625	67.625	30.750
10 years	3.375	62.50	34.125
11 years	3.250	62.625	31.00
12 years	5.50	38.50	56.00
13 years	4.125	45.0	50.875
14 years	3.375	44.250	52.375
15 years	4.750	26.625	68.625
16 years	4.875	39.625	56.750

assistance, as often the subject is virtually told the underlying principle. Since there is frequently somewhat less straight repetition than in the regrouping procedure, a more realistic estimate of success is obtained. The ability to spontaneously state the concept involved in the blocks is an undeniably appropriate measure of task success, but it is clearly a much more stringent criterion than either of the other two suggested variables.

Table 9 shows the percentage of subjects at each age level falling at each major Vygotsky stage. Subjects were categorized on the basis of the level assigned to each individual grouping, by placing them in the level in which most of their groups appeared. For example, if 25% of a subject's groups were indicative of Phase 1 (syncretic images), 50% were of the Phase 2 (complexes) type, and 25% were conceptual, he was rated at Phase 2. Overall, Phase 2 emerges as most dominant until 12 years, when Phase 3 gains majority. Interestingly, Phase 1 is never dominant, although 50% of the six year olds operated in terms of syncretic images. This finding supports the work of Stones and Heslop (1968) who found even less evidence of Phase 1 thought. Tables 8 and 9 reveal that even the most sophisticated subjects do use other levels of thinking as well, which is in accordance with Vygotsky's theory and is also borne out by Stones and Heslop.

Comparing Table 6 with Table 9 reveals that a number

TABLE 9

PERCENTAGE OF SUBJECTS FALLING AT EACH MAJOR VYGOTSKY STAGE ON THE BASIS OF LEVEL OF INDIVIDUAL RESPONSES

Age	Phase of Syncretic Images %	Phase of Complexes %	Phase of Conceptual Thinking %
4 years	37.5	62.5	
5 years	37.5	62.5	
6 years	50	50	
7 years		100	
8 years	12.5	87.5	
9 years		87.5	12.5
10 years		87.5	12.5
11 years		75	25
12 years		37.5	62.5
13 years		25	75
14 years		37.5	62.5
15 years		25	75
16 years		37.5	62.5

of subjects who are able to spontaneously state the principle involved in the blocks are not operating at the Phase 3 level, and a rare few who use a majority of conceptual groupings did not spontaneously verbalize the rule. This suggests that ability to verbalize cannot be considered a completely fool-proof criterion of Phase 3 thinking, although the two variables correlate at a highly significant level.

The percentages of subjects at each age level placed in the various Vygotsky stages by the raters are included in Table 10. Figures for this table were based on judgement of the subject's overall performance in terms of Vygotsky's original criteria. These subjective ratings were carried out entirely independently of the quantitative scoring, as only the writer was aware of the type of criteria on which other scores were based. Correlations between the raters' judgements (Table 11) were highly significant (.97 or better in all cases). This suggests that anyone reading Vygotsky's description of his stages can reliably assess performance on the Vygotsky Blocks. Here again, Phase 1 thinking never dominates, and Phase 3 comes to the fore at about 13 years of age. Comparing Table 10 with Table 9 reveals a generally similar pattern, although fewer subjects are placed in the Phase of Syncretic Images, and the raters tended to award Phase 3 at a younger age.

Variations between these two methods of assigning

TABLE 10

PERCENTAGE OF SUBJECTS PLACED AT EACH MAJOR VYGOTSKY STAGE BY THE RATERS

Age	Phase of Syncretic Images %	Phase of Complexes %	Phase of Conceptual Thinking %
4 years		100	
5 years	25	75	
6 years	50	50	
7 years		75	25
8 years		75	25
9 years		75	25
10 years		37.5	62.5
11 years		75	25
12 years		62.5	37.5
13 years		37.5	62.5
14 years		37.5	62.5
15 years			100
16 years		37.5	62.5

TABLE 11

CORRELATIONS BETWEEN THE VYGOTSKY SCORING VARIABLES AND THE RATERS RESULTS

Variable	Rater #1	Rater #2	Rater #3	Overall Vygotsky Stage, Based on Ratings of Individual Groupings
Time to First Grouping	-.259	-.266	-.256	-.217
Basis of First Grouping	.342	.334	.340	.294
Number of Examiner Clues	-.773	-.773	-.786	-.666
Total Time	-.584	-.597	-.598	-.419
Hypotheses Mentioned	-.179*	-.182*	-.212*	-.039*
Number of Different Hypotheses	.300	.289	.288	.351
Level of Verbalization (re: size)	-.666	-.680	-.679	-.508
Level of Verbalization (re: double dichotomy)	-.721	-.721	-.736	-.627
Time for Final Regrouping	-.433	-.429	-.425	-.371
Number of Final Errors	-.527	-.518	-.536	-.438
Rater #1		.982	.975	.683
Rater #2			.975	.683
Rater #3				.684

*Not significant at .05 or .01 level.

stage level indicates that the whole of the subject's performance is indeed different from the sum of its parts. Thus it seems that counting the individual group levels is quite similar to an overall judgement, but cannot be considered an exact substitute. The rater's judgements correlated with the more numerically derived overall level at .68, which is also highly significant. Comparing Tables 8 and 9 with Table 10 suggests the raters tended to place subjects on the basis of the highest level of thought they were capable of using, although it was necessary for the child to use the higher level with reasonable regularity in order to be rated at that level. This procedure is in accordance with Vygotsky's principles. Meece and Rosenblum's success criteria suggest more children operate at the conceptual level than the raters estimate, on the basis of the memory influenced factors; and that fewer reach Phase 3 on the basis of spontaneous verbalization. "Regrouping" results correlate .52 with the raters, and "Level of Verbalization" correlates with the raters between .66 and .73.

Table 11 illustrates the correlations between the individual Vygotsky scoring variables, the rater's results, and the overall individual groupings. As would be anticipated, the raters' judgements correlate more highly with the overall stage ratings than any single scoring dimension, since both of these variables are based on

Vygotsky's original descriptions of stage characteristics.

All individual scoring procedures correlate significantly with the rater's data and the "Overall Stage" dimension except "Number of Hypotheses Mentioned" (Table 12). This is as would be expected, as the measure in question correlated with the fewest other variables and did not relate to age. As had been previously mentioned, Meece and Rosenblum argue that such a measure deserves a place in the scoring battery on the basis of its very independence. All other variables emerge as reliable indicators of various aspects of Vygotsky performance, but the tables illustrate that none resemble the ratings closely enough to be considered a valid single criterion of cognitive level. "Level of Verbalization" appears to be the most reliable individual score, as it is the best predictor of age level and correlates highly with the rater's data, and with the overall rating derived from individual groupings. The importance of the verbal factor has also been noted by other researchers (Meece and Rosenblum, 1965; Stones and Heslop, 1968; and Stones, 1970). The best single non-verbal indicator of Vygotsky performance is the number of examiner clues required for the subject to successfully complete the task. This measure was the second best predictor of age, and correlated the highest with the rater's judgements and the overall rating from individual groupings. Thus "Number of Clues" seems a more suitable performance-type criteria

TABLE 12

HARTLEY TEST FOR HOMOGENEITY OF VARIANCE ON THE SUITABLE VYGOTSKY MEASURES

Variable	Smallest Variance	Largest Variance	$F\ max = \frac{\text{largest variance}}{\text{smallest variance}}$
Time to First Grouping	9169.6406	402.2141	22.7979
Total Time	114.7857	20.6964	5.5461
Number of Hypotheses	164.4107	10.7857	15.2433
Number of Different Hypotheses	14.5714	2.7857	5.2307
Level of Verbalization (re: double dichotomy)	.2857	.125	2.2856

than "Number of Errors in the Final Regrouping" as suggested by Meece and Rosenblum, the limitations of which have previously been discussed.

The Hartley Test for homogeneity of variance was carried out on all age groups of Vygotsky variables suitable for analysis of variance among age levels; i.e. those involving no zero variances. These results reveal that all measures involve sufficiently similar variances to permit use of this method of analysis. The analysis of variance summary for the Vygotsky data is found in Table 13. All F values are significant with the exception of "Time to first grouping," which suggests that non-chance variations do exist somewhere among the age levels in the majority of these variables. The lack of significance in the "Time" measure is undoubtedly a factor of the very large mean square error term, which means that there was a great deal of variation within each individual age group in this regard. The exact nature of the significant differences between age levels on the remaining variables was explored using the Scheffe contrast. On the "Total Time" scores only age 6 contrasted with age 15 emerged as significantly different (P= .026), and on "Number of Different Hypotheses", age 4 differs from age 9 (P= .05). "Level of Verbalization re: double dichotomy yielded the most significant results as ages 4,5, and 6 differed from all other ages except 7 years, with probabilities ranging from

TABLE 13

SUMMARY OF ANALYSIS OF VARIANCE FOR VYGOTSKY VARIABLES

Variable	Source	Sum of Squares	Mean Square	DF	F	P
Time to First Grouping	Groups	0.386	3212.79	12	1.76	0.067
	Error	0.166	1826.34	91		
Total Time	Groups	0.240	199.61	12	3.12	0.001**
	Error	0.583	64.03	91		
Number of Hypotheses	Groups	0.155	129.38	12	2.06	0.027*
	Error	0.571	62.78	91		
Number of Different Hypotheses	Groups	0.314	26.17	12	4.33	0.000**
	Error	0.550	6.04	91		
Level of Verbalization (re: double dichotomy)	Groups	0.359	2.99	12	13.43	0.000**
	Error	0.203	0.22	91		

0.00 at the highest ages to 0.042 at 8 and 9 years. No significant differences were found between age levels on the "Number of Hypotheses" dimension, in spite of the overall significant F, owing to the rigor of the Scheffe test.

The significance of difference among age levels on the remaining Vygotsky variables was investigated using t tests on all age groups that did not have zero variance. Significant findings only are reported in Table 14. In cases where the F test yielded significant differences between the variances of the ages in question, the Welch t prime adjustment for this circumstance is included as well. The greatest change in manner of response occurs between 6 and 7 years of age, as three individual scoring variables show significant differences here, and all three raters awarded significantly higher ratings to the older group. One rater distinguished between the 9 and 10 year olds; two raters scored the 14 year olds significantly lower than the 15 year olds and the 15 year olds significantly higher than the 16's. Changes in the other variables tend to come before 7 years of age. Four year olds cannot explain the size aspect involved in the blocks as well as the 5 and 6 year olds, who in turn perform significantly poorer than the age 7 group in this regard. An identical pattern is seen for "Number of Errors in the Final Regrouping." Age 5 requires significantly fewer examiner clues than age 6, who require more clues than age 7. Surprisingly, 5 year olds

TABLE 14

SUMMARY OF SIGNIFICANT T TESTS BETWEEN AGE LEVELS ON THE VYGOTSKY VARIABLES

Age Variable	$\overline{X}$ 1	$\overline{X}$ 2	T	P-One Tail	P-Two Tail	F-test for Differences of Variance	P-Non-Directional	Welch T' Adjustment	P-One Tail	P-Two Tail
Age 4 vs. 5										
Level of Verbalization (re: size)	2.87	2.37	2.256	0.02	0.04	2.143	0.34			
Number of Errors	16.50	6.37	3.51	0.0017	0.0034	1.619	0.54			
Age 5 vs. 6										
Number of Clues	21.50	20.50	1.764	0.049	0.099	3.5	0.12			
Time for Final Grouping	59.38	186.00	-2.534	0.012	0.024	41.053	0.0001	-2.534	0.019	0.037
Age 6 vs. 7										
Number of Clues	20.50	16.75	1.987	0.033	0.066	13.25	0.003	1.987	0.041	0.082
Level of Verbalization	2.25	1.50	3.00	0.005	0.010	1.333	0.714			
Number of Errors	8.50	2.37	2.377	0.016	0.032	2.879	0.186			
Rater 1, 2, 3	5.37	9.37	-3.028	0.004	0.009	1.334	0.713			
Age 9 vs. 10										
Rater 3	9.50	11.50	-1.815	0.0455	0.091	1.429	0.650			
Age 15 vs. 16										
Rater 2 & 3	13.62	12.00	2.489	0.013	0.026	11.733	0.004	2.489	0.018	0.036
Age 14 vs. 15										
Rater 1 & 2	10.37	13.62	-1.924	0.037	0.074	84.2	0.00004	-1.924	0.047	0.095

assemble the final regrouping much more quickly than those aged 6 years.

A graphic presentation of the means of each age group for each Vygotsky variable are found in Figures 1-14. Of the variables subjected to analysis of variance, only "Level of Verbalization" exhibits a pattern indicative of age dependent stages of sophistication, as ages 4, 5, and 6 perform similarly and significantly differently from all the older subjects. The transition from one stage to another occurs at age 7 on this variable. Scheffe contrasts on the other variables showing significant results served only to distinguish the lowest from the highest mean scores. Of all the non-significant Scheffe scores obtained, only one other contrast even approached significnace (age 6 vs age 14 on Total Time with a p of 0.083). Thus it seems doubtful if many more significant results would have been found even using a less stringent criterion than the Scheffe.

As the t tests could not be used to compare all means for a given variable, it is much more difficult to assess obtained results in terms of developmental stage considerations. It is possible however, to gain some idea of the overall pattern of sophistication by comparing the t test results with the graphs of the means for each variable. "Level of Verbalization re: Size" closely resembles the stages formed by the double dichotomy measure, except that in this case the 5 and 6 year olds seem to form an

MEANS OF EACH AGE GROUP FOR THE "TIME TO FIRST GROUPING"
VYGOTSKY VARIABLE

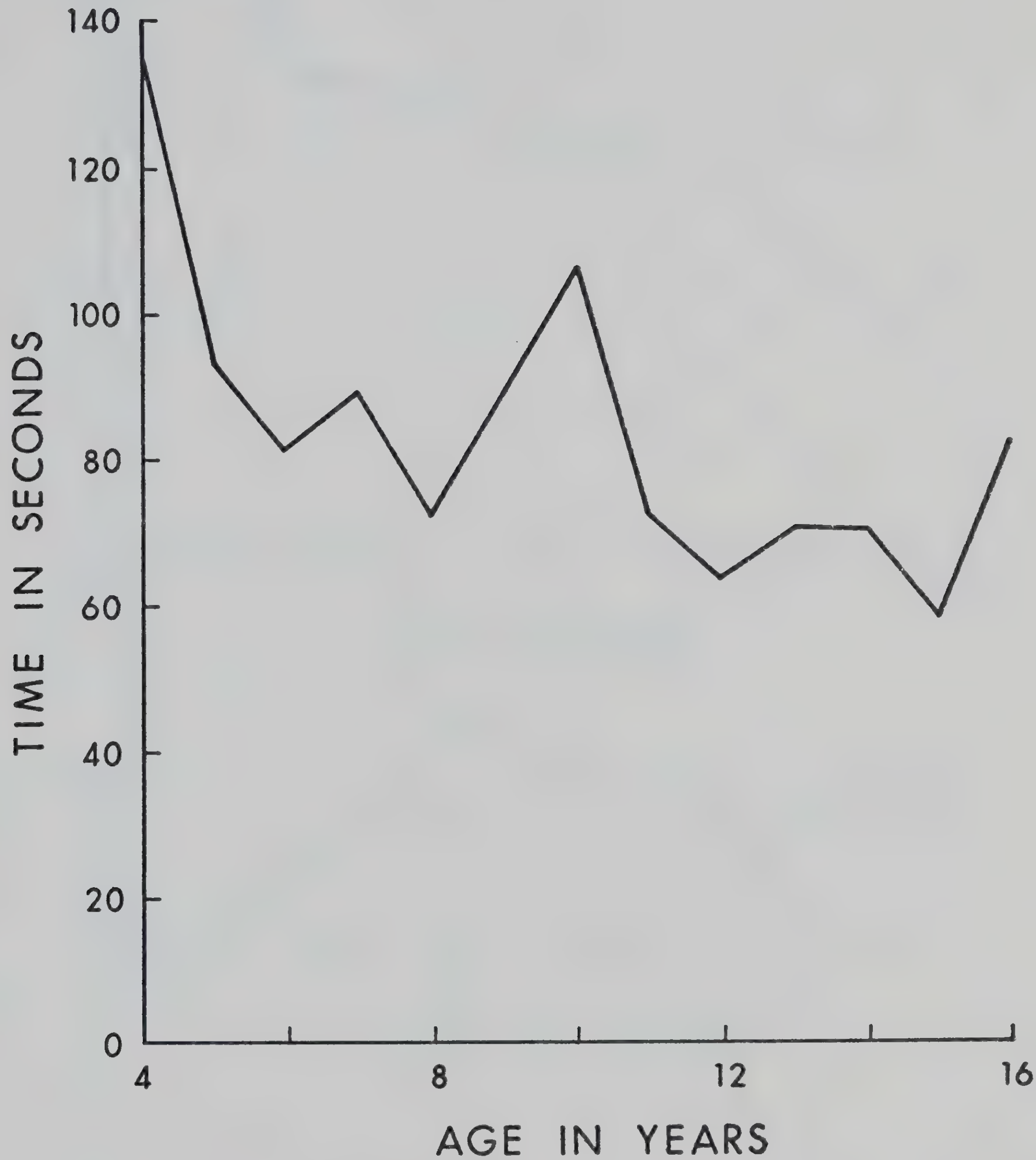


Figure 1.

MEANS OF EACH AGE GROUP FOR THE "NUMBER OF EXAMINER CLUES"
VYGOTSKY VARIABLE

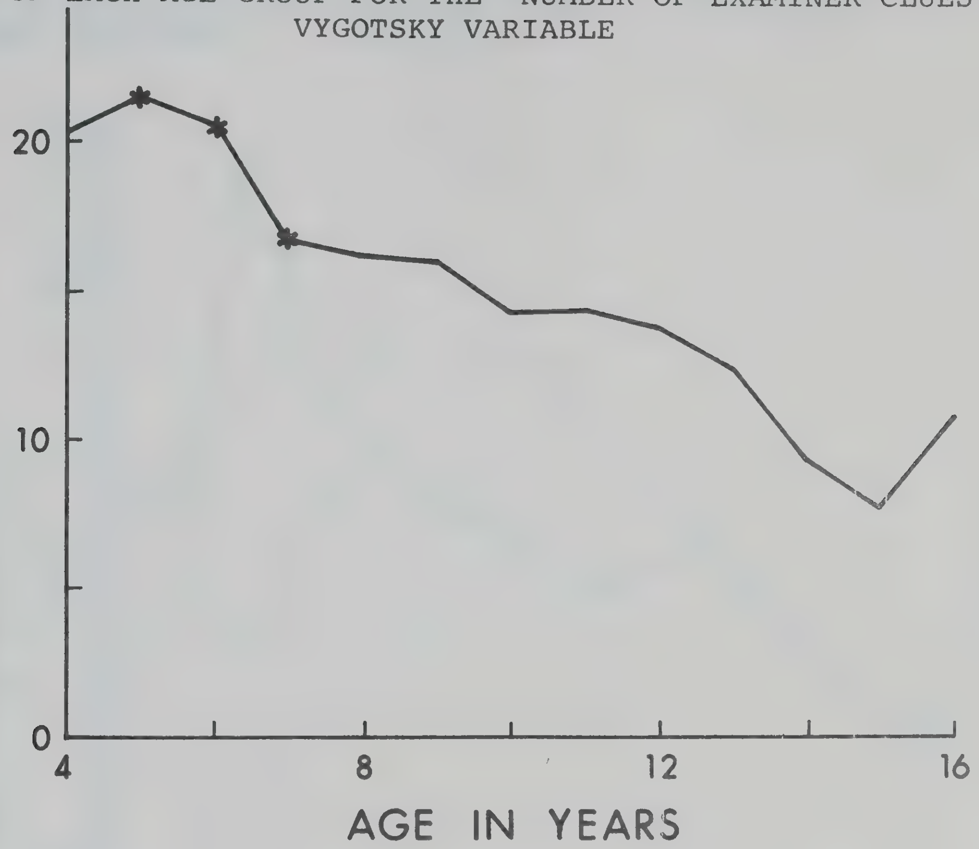
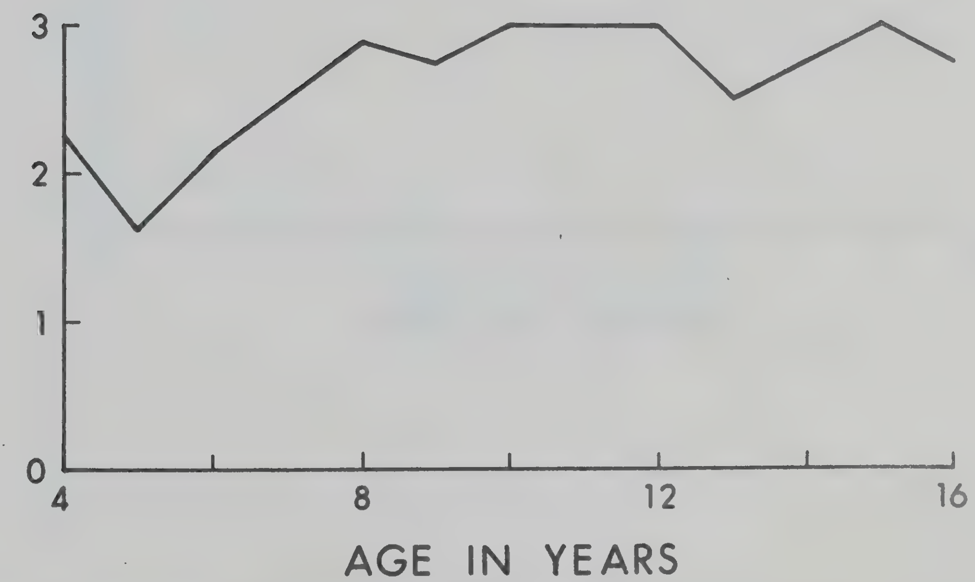


Figure 2.



MEANS OF EACH AGE GROUP FOR THE "BASIS OF FIRST GROUPING"
VYGOTSKY VARIABLE

Figure 3.

MEANS OF EACH AGE GROUP FOR THE "TOTAL TIME REQUIRED" VYGOTSKY VARIABLE

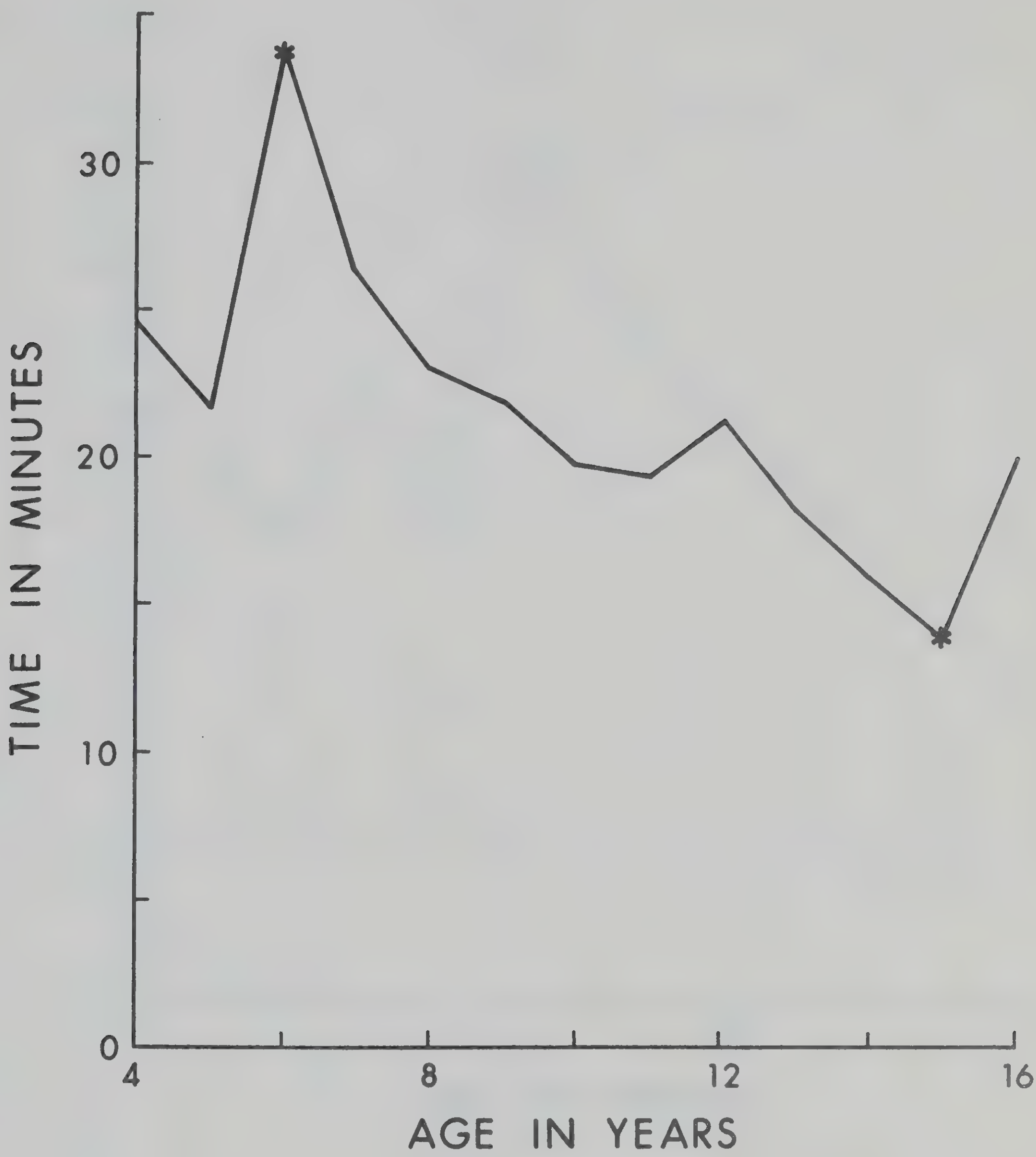


Figure 4.

MEANS OF EACH AGE GROUP FOR THE "TOTAL NUMBER OF HYPOTHESES" VYGOTSKY VARIABLE

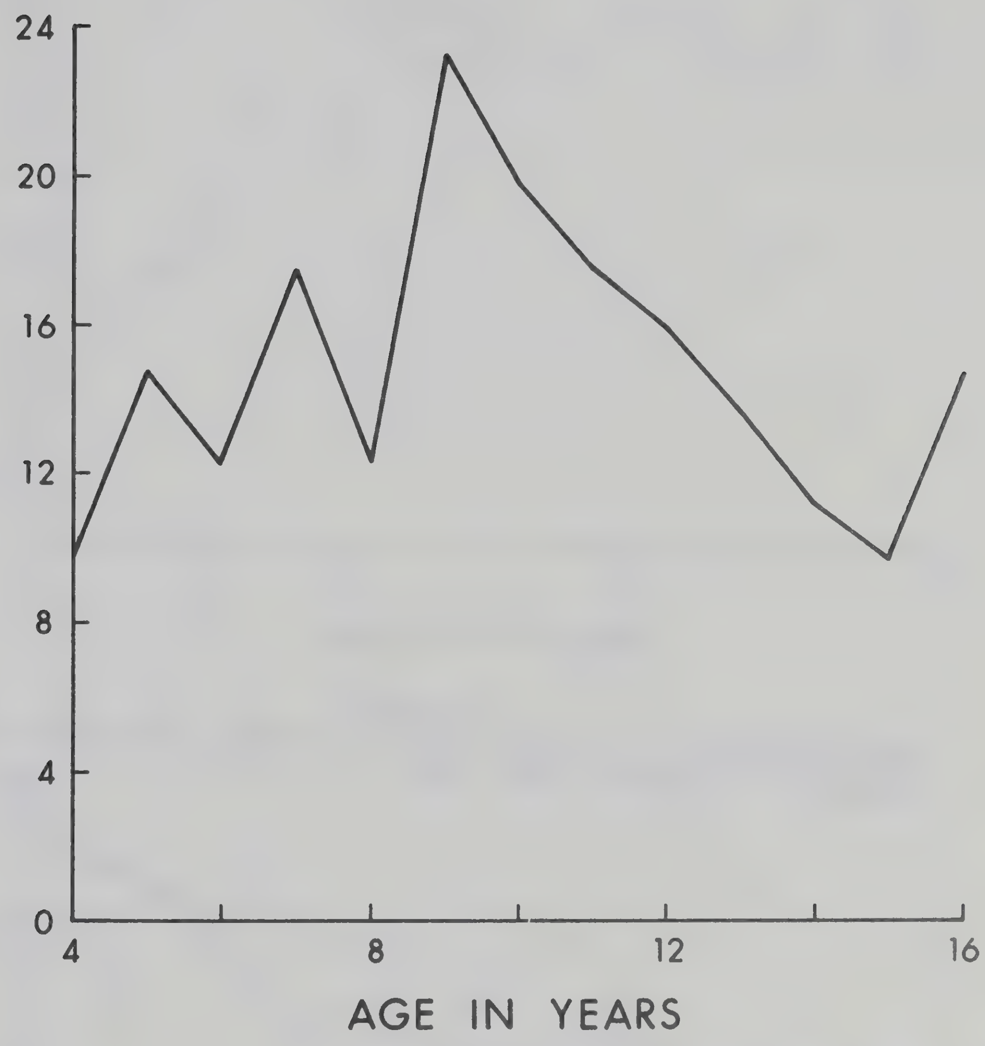


Figure 5.

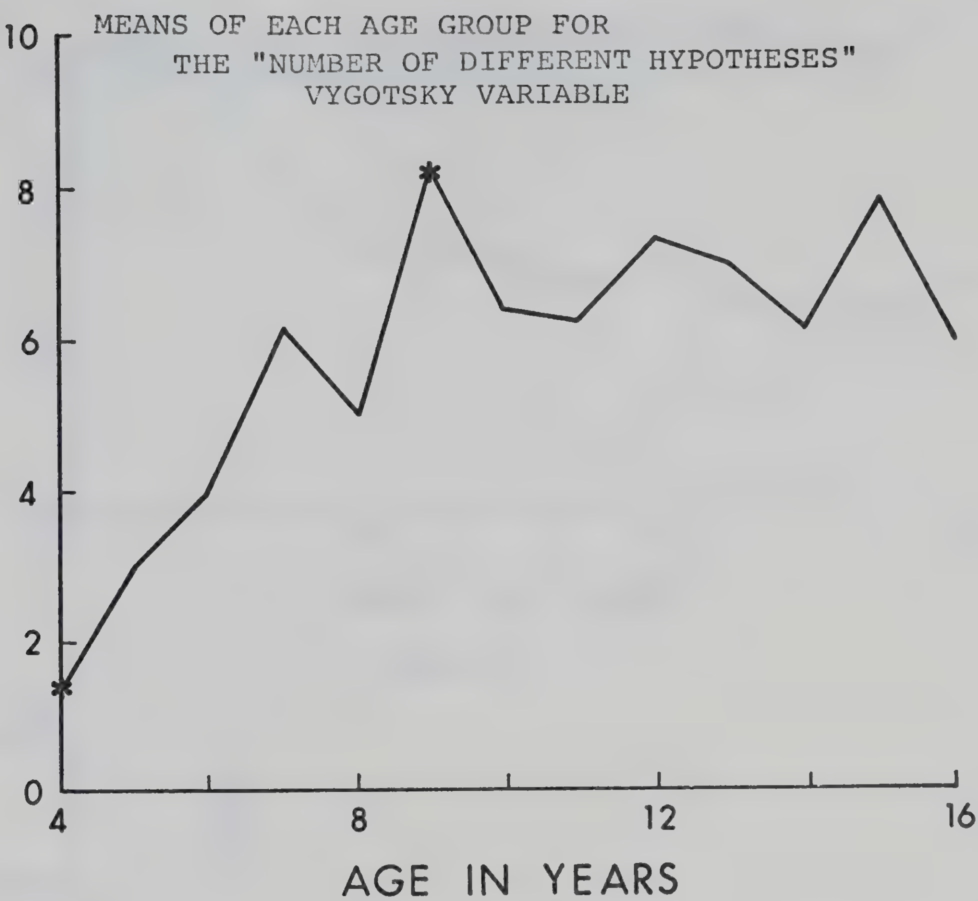


Figure 6.

MEANS OF EACH AGE GROUP FOR THE "LEVEL OF VERBALIZATION
RE: SIZE" VYGOTSKY VARIABLE

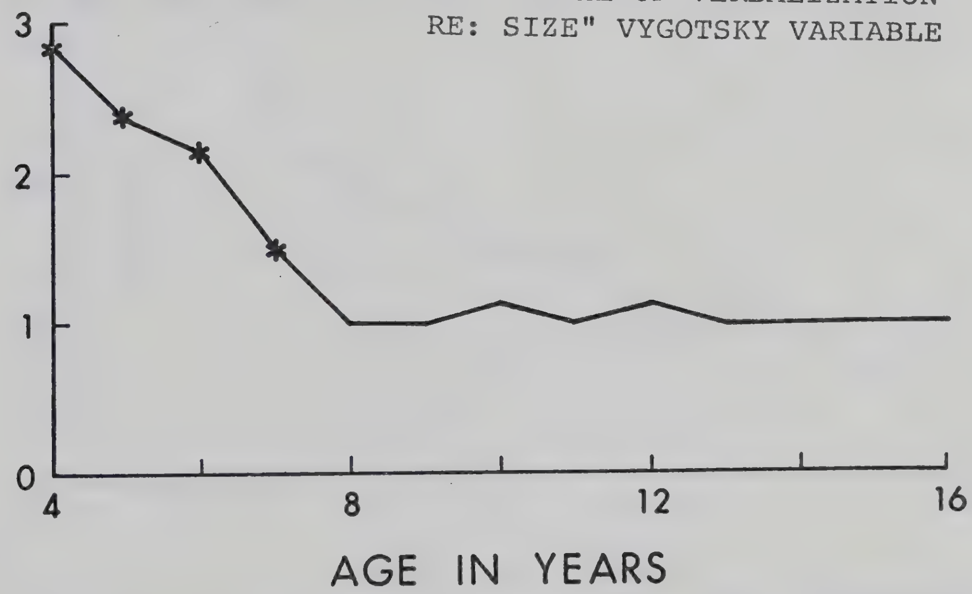


Figure 7.

MEANS OF EACH AGE GROUP FOR THE "LEVEL OF VERBALIZATION RE: DOUBLE DICHOTOMY" VYGOTSKY VARIABLE

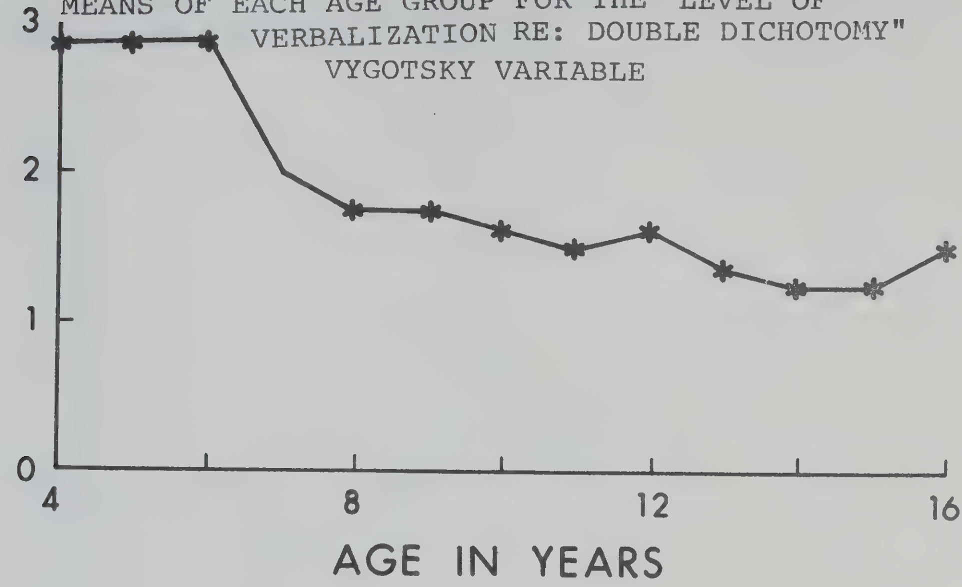
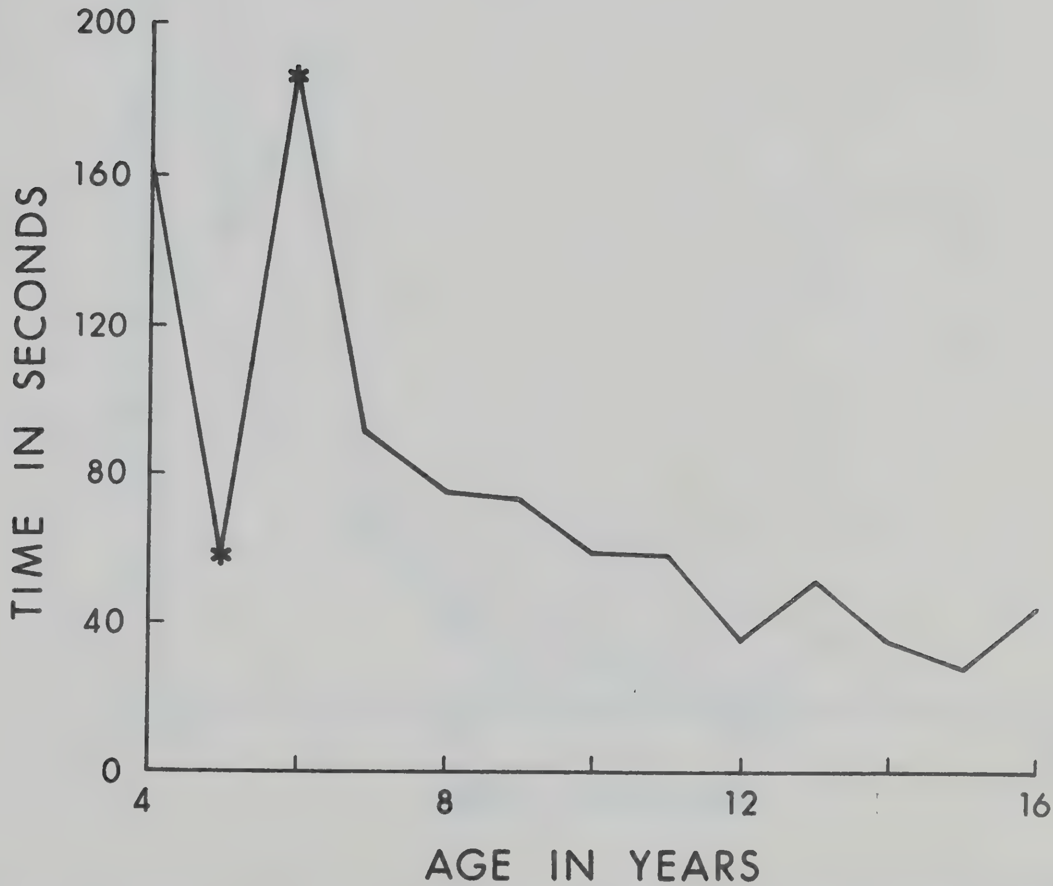


Figure 8.



MEANS OF EACH AGE GROUP FOR THE "TIME FOR FINAL REGROUPING" VYGOTSKY VARIABLE

Figure 9.

MEANS OF EACH AGE GROUP FOR THE "NUMBER OF ERRORS IN THE FINAL REGROUPING" VYGOTSKY VARIABLE

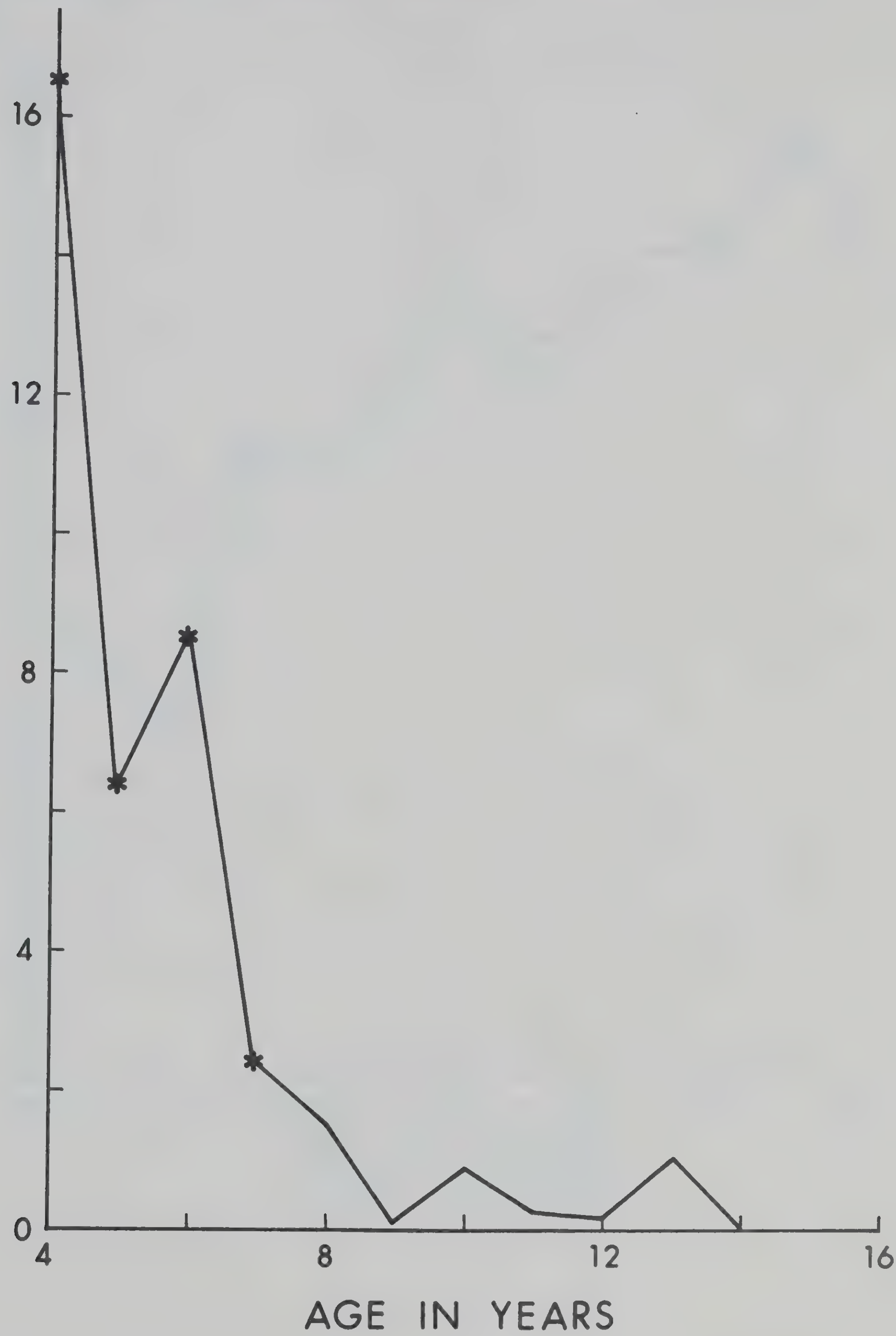


Figure 10.

MEANS OF EACH AGE GROUP FOR RATER NUMBER ONE

Figure 11.

MEANS OF EACH AGE GROUP FOR RATER NUMBER TWO

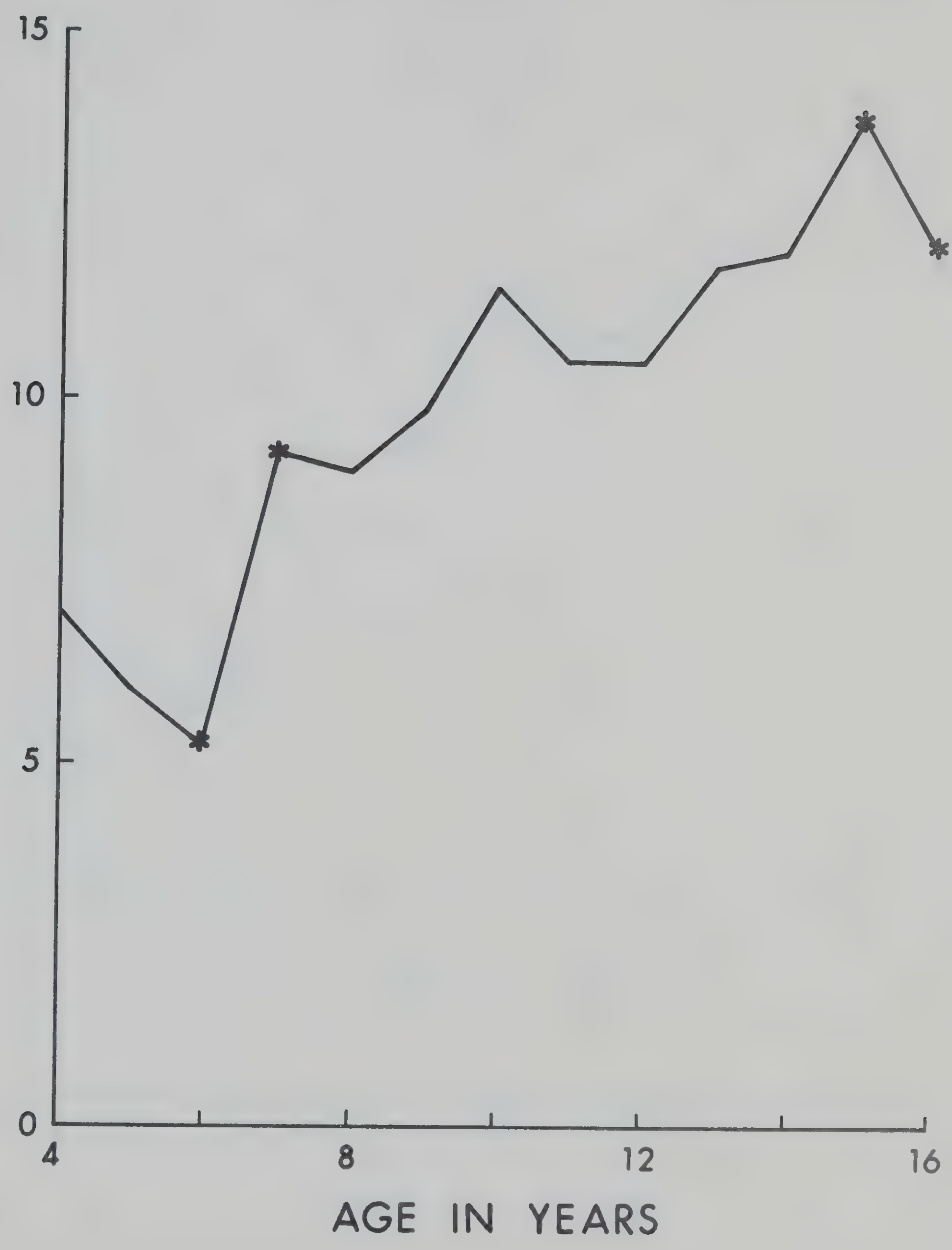


Figure 12.

MEANS OF EACH AGE GROUP FOR RATER NUMBER THREE

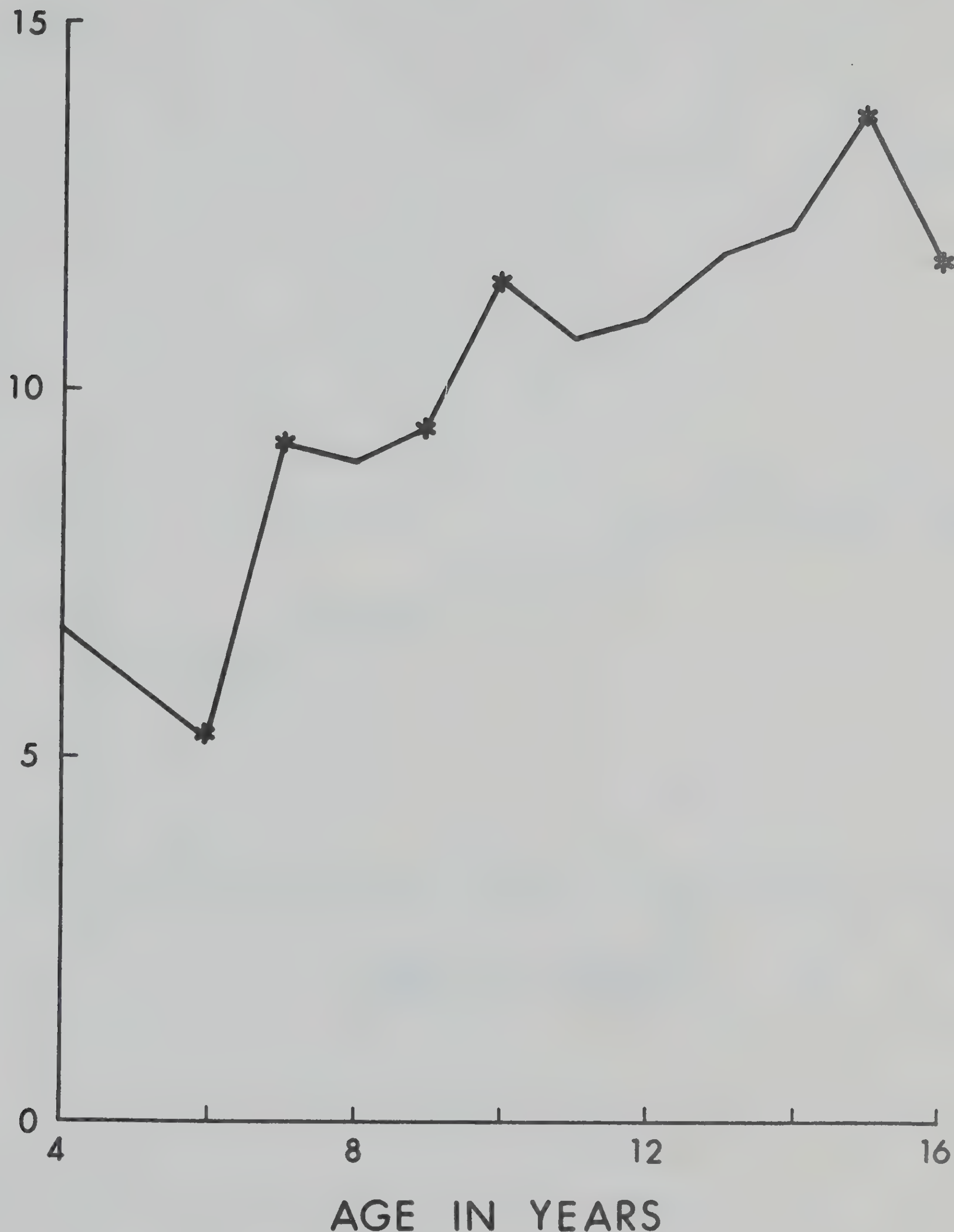


Figure 13.

MEANS FOR EACH AGE GROUP ON THE OVERALL STAGE DERIVED FROM THE INDIVIDUAL GROUPINGS OF THE VYGOTSKY BLOCKS

Figure 14.

intermediate stage, between the older children and the four year olds. A similar pattern is also observed with regard to the number of errors in the final regrouping. The performance of the four youngest age levels was significantly different from the older subjects on "Number of Examiner Clues", but in this case the means gradually and steadily increased throughout the year levels, raising the possibility that other variations may exist that could not be tested. The only other measure exhibiting significant variation was "Time for Final Regrouping", which yielded a very irregular pattern, as the 5 year group performed uncommonly well.

All three raters appear to distinguish between the three youngest groups and the rest of the sample, which suggests two definite stages of sophistication. Two of the raters also differentiate between the 14 and the 15 year olds, which may define the highest stage of cognitive development. The 16 year olds spoil the pattern however, as two raters judged them significantly poorer than the 15 year olds. One rater's data showed an additional intermediate stage, composed of the 7, 8, and 9 year olds.

In summary, analysis of variance between age levels revealed that five individual scoring variables showed evidence of two clear cut stages of competence in performance of the Vygotsky Blocks. These variables were: the number of examiner clues provided; the level of

verbalization re: size and double dichotomy; the time for final regrouping; and the number of errors in the final regrouping. Stage one included ages 4, 5, and 6 and Stage two was composed of the remainder of the age levels. The rater's data concurred with this, but gave additional evidence of a third level of sophistication at 15 years of age. One rater did not yield this adolescent distinction, but differentiated instead between ages 9 and 10. None of the individual scoring methods displayed any significant differences in performance after age 7. This suggests that either the ceiling value on a given scale is reached at a relatively young age, and/or that performance improves gradually as a function of age without definite stages emerging. The latter explanation appears appropriate for all measures except "Number of Hypotheses Mentioned," as these variables correlate highly with age.

The means and standard deviations for all scoring variables used on the Vygotsky Blocks are included in Table 15. It was the hope of Meece and Rosenblum that these measures would eventually evolve into children's norms for the Blocks Test; thus it is interesting to compare the results obtained on their sample of fifty 12 year olds with the present data, as in Table 16. The findings from both studies are remarkably similar on the majority of the scoring dimensions, especially in view of the fact that there are only eight subjects per age level in the present

TABLE 15

MEANS AND STANDARD DEVIATIONS OF TEN MEASURES OF VYGOTSKY TEST PERFORMANCE

Variable	Age	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Total Time (min.)	M	24.5	21.75	33.875	26.375	23.0	21.875	19.75	19.375	21.25	18.125	15.875	13.875	20.0	21.510
	SD	7.910	4.862	7.624	10.085	7.616	6.978	10.714	5.013	9.051	10.453	8.043	4.549	7.946	8.891
Number of Clues	M	20.25	21.5	20.5	16.75	16.25	16.0	14.25	14.375	13.75	12.375	9.375	7.75	10.75	14.914
	SD	2.435	0.756	1.414	5.148	4.432	5.732	6.756	4.373	5.849	6.589	4.627	3.919	4.833	6.020
Time for First Grouping (sec.)	M	136.25	91.875	81.0	88.75	72.5	80.5	101.75	72.5	63.625	70.875	70.625	58.125	82.375	82.365
	SD	95.759	23.288	45.286	20.055	20.591	44.890	39.133	40.750	28.147	21.122	45.576	21.203	46.702	44.371
Level of Verbalization (size)	M	2.875	2.375	2.25	1.5	1.0	1.0	1.25	1.0	1.125	1.0	1.0	1.0	1.0	1.414
	SD	0.354	0.517	0.463	0.535	0.0	0.0	0.463	0.0	0.354	0.0	0.0	0.0	0.0	0.688
Level of Verbalization (double dichotomy)	M	2.875	2.875	2.875	2.0	1.75	1.75	1.625	1.5	1.625	1.375	1.25	1.25	1.5	1.865
	SD	0.354	0.354	0.354	0.535	0.463	0.463	0.518	0.534	0.518	0.518	0.463	0.463	0.535	0.735
Time for Final Grouping (sec.)	M	165.875	59.375	186.0	91.875	76.25	73.125	59.875	59.375	36.625	51.125	36.5	28.5	43.75	74.481
	SD	107.254	21.791	136.620	33.078	46.460	30.309	38.069	30.734	17.960	52.982	28.340	7.407	26.304	71.108
No. of Errors in Final Group	M	16.5	6.375	8.5	2.375	1.5	.125	.875	.25	.125	1.5	0.0	0.0	0.0	2.933
	SD	6.414	5.041	6.280	3.701	2.139	0.354	2.475	0.707	0.354	4.243	0.0	0.0	0.0	5.649
Total Number of Hypotheses	M	9.5	14.875	12.25	17.5	12.375	23.25	19.875	17.5	16.0	13.625	11.125	9.75	14.625	14.788
	SD	6.165	10.191	8.648	5.880	5.878	10.389	12.823	6.887	6.279	8.847	5.027	3.284	7.539	8.358
No. of Different Hypotheses	M	2.75	3.0	4.0	6.25	5.0	8.5	6.875	6.5	7.625	7.0	6.375	6.25	7.875	6.000
	SD	1.753	2.0	2.204	1.909	3.505	3.817	3.137	2.138	1.768	2.449	1.996	1.669	2.417	2.882
Basis of First Grouping	M	2.25	1.625	2.125	2.5	2.875	2.75	3.0	3.0	3.0	2.50	2.75	3.0	2.75	2.625
	SD	0.886	0.916	0.991	0.756	0.354	0.707	0.0	0.0	0.0	0.926	0.707	0.0	0.707	0.736

TABLE 16

MEANS AND STANDARD DEVIATIONS OF VYGOTSKY PERFORMANCE FOR 11-12 YEAR OLDS (FROM MEECE AND ROSENBLUM'S 1965 STUDY, AND THE PRESENT INVESTIGATION)

Variable		Present 11's ($\overline{X}$ age=11 yr. 6 mo.)	M. & R.'s 12's ($\overline{X}$ age=12 yr. 0 mo.)	Present 12's ($\overline{X}$ age=12 yr. 6 mo.)
Total Time (min.)	M	19.37	20.13	21.25
	SD	5.01	8.35	9.05
Number of Clues	M	14.37	12.44	13.75
	SD	4.37	5.55	5.84
Time for First Grouping (sec.)	M	72.5	180.1	63.62
	SD	40.75	90.0	28.15
Level of Verbalization (size)	M	1.0	1.58	1.13
	SD	0.0	.72	.35
Final Time (sec.)	M	59.37	40.20	36.62
	SD	30.73	20.95	17.96
Final Errors	M	.25	.16	.125
	SD	0.71	.46	0.35
Total Number of Hypotheses	M	17.5	9.34	16.0
	SD	6.88	3.84	6.27
Number of Different Hypotheses	M	6.5	3.68	7.62
	SD	2.14	1.24	1.76
Level of Verbalization (double dichotomy)	M	1.5		1.625
	SD	0.53		0.52

sample. Meece and Rosenblum report that their 12 year olds took nearly two minutes longer to form the initial group and used somewhat fewer hypotheses, as well as many fewer different kinds of hypotheses as the basis of their groupings. The magnitude of variation between the two studies on these variables suggests that perhaps differences in methods of scoring are being reflected, rather than real discrepancies in sample performance. It is entirely possible that the present examiner was not sufficently diligent to co-ordinate timing with the first glimpse of the blocks. In the present experiment, the subject was given credit for two hypotheses if he gave more than one reason for a given physical configuration of the blocks, which may account for the higher number found here. Some variation was expected on the "Different Hypotheses" dimension, as the Penny classifications employed here probably differed somewhat from the original criteria. Breaking the "Level of Verbalization" into two parts appears to have had little effect, judging from the similarity of scores in the two experiments.

Obtained statistical results compare favorably with those of both Stones and Heslop, and Meece and Rosenblum (as well as Thompson's 1941 work, on which the latter study was based). Thus it seems legitimate to regard present data as suitable preliminary norms of childrens' performance on the Vygotsky blocks, pending future work using larger samples at

various ages.

The present investigation thus appears reasonably valid quantitatively, but what of the even more vital qualitative concerns? How well do these findings fit with Vygotsky's original model of the development of children's cognitive functions? The answer to this question requires a more detailed scrutiny of the rater's judgements, in terms of substages as well as major phases. This information is contained in Table 17. At least one child in the sample was found to be operating primarily in terms of each of Vygotsky's proposed substages, except the perceptual stage of the Phase of Syncretic Images. This seems to be in keeping with the findings of Stones and Heslop, which is the only other study to date to investigate children's responses in terms of Vygotsky's substages. They report that "examples of the same three broad categories of grouping and most of the sub-categories were observed", but do not elaborate as to which specific substages they found (1968, p. 269). On this basis Stones and Heslop conclude that their findings bear out those of Vygotsky, as much the same modes of thinking which he observed occurred in their sample as well. Stones and Heslop thus consider the Vygotsky model of concept formation an appropriate one.

Present results also attest to the validity of Vygotsky's theoretical model, but the relative frequency of the various categories raise the possibility of some minor

TABLE 17

PERCENTAGE OF SUBJECTS PLACED IN EACH VYGOTSKY STAGE BY THE RATERS

Vygotsky Stage	Age	4	5	6	7	8	9	10	11	12	13	14	15	16
Phase of Syncretic Images			25	50										
Trial and Error Stage				12.5										
Perceptual Stage														
Composite Stage			25	37.5										
Phase of Complexes		100	75	50	75	75	75	37.5	75	62.5	37.5	37.5		37.5
Associative Stage		50	50	25	12.5	12.5	12.5	12.5		12.5				
Collection Stage				12.5	12.5	25								
Chain Stage		37.5	25				25				12.5			
Diffuse Stage						12.5			12.5		12.5	25		
Pseudo-Conceptual Stage		12.5		12.5	50	25	37.5	25	62.5	50	12.5	12.5		37.5
Phase of Conceptual Thinking					25	25	25	62.5	25	37.5	62.5	62.5	100	62.5
Partial Abstraction Stage							12.5	25	12.5					12.5
Potential Concepts					25	25	12.5	25			25	25	50	25
Genuine Concepts								12.5	12.5	37.5	37.5	37.5	50	25

modification. As previously mentioned, the Phase of Syncretic Images occurs quite rarely; however, the fact that it represents the type of cognition used by at least some of the sample renders it a necessary part of the model. Examination of the substages of this phase reveals that all except one of these children who operate at this level employ a composite approach, as they use both trial and error and perceptual responses. This suggests that perhaps the composite subphase may be virtually equated with the first major phase, thus these first three subphases appear unnecessary. All subcategories under the other two major phases represent a reasonable proportion of the subjects, thus must be legitimately retained in the theoretical framework. Present data therefore supports all aspects of Vygotsk's model, except the inclusion of subphases within the Phase of Syncretic Images.

Although Vygotsky describes his cognitive categories in detail, he provides little information about the ages at which these stages may be expected to occur, or their frequencies of appearance. As can be seen from Table 16, in the present study, the Phase of Syncretic Images never represents the majority of responses at any age level, and does not occur at all beyond age 6. The Phase of Complexes, on the other hand, largely dominates until age 13, when the Phase of Conceptual Thinking comes to the fore. The associative substage is particularly popular with the 4 and

5 year olds and is used quite consistently until age 12. The pseudo-conceptual category is overall the most frequent type of response, as it accounts for a quarter of the sample subjects, and occurs at all age levels except 5 and 15 years. This substage is particulary evident at 11 and 12 years, where it acccunts for at least half of all responses. The other substages of the second major phase are less common, but do occur. The collection stage is the most rare, as it is found only between ages 6 and 8. The chain stage is popular with the youngest subjects, but is also seen at ages 9 and 13. The diffuse stage occurs more among the older subjects of 11 and 14 years, but also appears at age 8. The final phase of conceptual thinking first emerges at age 10, but does not consistently dominate until 13 years. The partial abstraction stage is the rarest of the phase 3 substages, as it is fcund between 8 and 10 years as well as at age 16. Pctential concepts and genuine concepts are the second most common of Vygotsky's subcategories, as they each account for 16 per cent of the subjects in the sample. Potential concepts emerge as early as age 7, and continue to appear at all ages except 10 and 11. Genuine concepts are first seen at 10 years and steadily gain prominance until age 15, with a slight drop at 16 years.

Comparing the patterns of response occurring in this study with the few remarks Vygotsky makes in this regard, reveals considerable similarity between the theoretical and

the obtained model. As previously discussed, the earliest substages were not borne out by these findings, but the latter categories compare well. The associative stage emerges as the earliest type of complex regularly employed, which is gradually supplemented by collection groupings, as Vygotsky hypothesized. Chain complexes appear at an earlier age level than collections, thus contradicting Vygotsky's proposed order of appearance somewhat. However they do continue to be used to a much later age, which suggest perhaps they may legitimately be considered a more mature form of complex. The diffuse stage does emerge later than the other subphases and is found to an even higher age; thus it appears to be appropriately placed. Vygotsky considers the pseudo-concept a bridge between complexes and concepts, and believes this type of concept predominates over all others during the second phase of development. Both these assertions appear to be confirmed by present data, as this type of grouping is by far the most common.

Vygotsky considers the complex thinking found in Phase 2 to be one root of concept formation, and the types of problem solving found in Phase 3 to be a second and independent root, which has a distinct genetic function in the child's mental development. This description suggests that Phase 3 would not necessarily be expected to appear at a later chronological age than Phase 2, although Vygotsky also notes that genuine concepts appear only at puberty. On

this basis one might expect to find the two earliest stages of Phase 3 occurring well before adolescence, with the formation of genuine concepts considerably later. This pattern is borne out by the data. Vygotsky states that the processes leading to genuine concepts develop along two main lines: the formation of complexes, and the formation of potential concepts. This suggests that the partial abstraction stage is relatively rare, and that potential concepts would be expected to appear from a relatively young age, as in fact occurred here. Children do operate largely in terms of the Phase of Conceptual Thinking from age 13 on; however, not all adolescents are capable of using genuine concepts. In actuality the percentage of children at a given age level who operated primarily in terms of this highest stage never exceeded 50. Vygotsky does not discuss the frequency of genuine concepts, so the present finding does not necessarily contradict his ideas; however, the fact that all children do not reach the highest levels of conceptual development by age 16 is of considerable significance.

In summary, present findings strongly support the validity of most aspects of Vygotsky's model of cognitive development. However, statistical analysis of individual scoring variables did not reflect a similar developmental pattern, although the various measures emerged as appropriate methods of analyzing performance. This suggests

that the individual scores could be used to create norms for comparison of a child's performance relative to that of his peers, but actual judgement of cognitive level must be made on a purely qualitative basis, in accordance with Vygotsky's subjective criteria.

Results Obtained From the Piagetian Investigation

The t tests applied to the male and female subjects for all Piagetian tasks are reported in Table 18, with the corresponding F scores included in Table 19. Here, as on the Vygotsky analysis, no significant differences were found between the performance of the sexes for either conservation or explanation scores. Thus H_4 is confirmed, and the data for both sex groups were combined for use in all other computations. Goldschmid (1967) gave similar tasks to children aged 7-9 years and used the same scoring procedure as the present study, but found males performed better than females on every task. The difference reached significance for the Substance and Discontinuous Quantity problems, and for all total scores computed. Present results as well as the findings of most other investigators, support Piaget's position in this regard, as he has never hypothesized sex differences (Papalia, 1972; Uzigris, 1964).

The correlations among all Piagetian tasks are found in Table 20, and the correlations between the individual areas and the total scores are reported in Table 21. All obtained values are positive and all are highly significant,

TABLE 18

T-TESTS BETWEEN MALES AND FEMALES ON THE PIAGETIAN TASKS

	Mean - Males	Mean - Females	Standard Deviation - Males	Standard Deviation - Females	DF	T	P-One Tail	P-Two Tail
Conservation of Substance								
(Conservation Score)	4.50	4.44	2.53	2.53	102	0.116	0.454	0.908
(Explanation Score)	4.35	4.13	2.50	2.58	102	0.425	0.336	0.672
Conservation of Continuous Quantity								
(Conservation Score)	4.65	4.54	2.50	2.54	102	0.234	0.408	0.816
(Explanation Score)	4.44	4.52	2.55	2.49	102	-0.156	0.438	0.877
Conservation of Discontinuous Quantity								
(Conservation Score)	4.65	4.65	2.50	2.50	102	0.0	0.500	1.000
(Explanation Score)	4.40	4.37	2.53	2.54	102	0.077	0.469	0.939
Conservation of Weight								
(Conservation Score)	4.15	3.92	2.71	2.69	102	0.436	0.332	0.664
(Explanation Score)	4.12	3.90	2.70	2.81	102	0.392	0.348	0.696
Conservation of Area								
(Conservation Score)	7.04	6.58	2.19	2.92	102	0.912	0.182	0.364
(Explanation Score)	6.65	6.37	2.66	3.04	102	0.516	0.304	0.607
Conservation of Volume								
(Conservation Score)	1.19	1.38	2.28	2.43	102	-0.416	0.339	0.678
(Explanation Score)	1.12	1.13	2.22	2.12	102	-0.045	0.482	0.964
Conservation of Density								
(Conservation Score)	4.52	4.62	2.72	2.98	102	-0.172	0.432	0.864
(Explanation Score)	2.63	2.60	2.88	3.½8	102	0.065	0.474	0.949
Formal Operations Question	0.77	0.73	0.98	0.97	102	0.201	0.421	0.841

TABLE 19

F-TESTS OF DIFFERENCE BETWEEN MALE AND FEMALE VARIANCES ON THE PIAGETIAN TASKS

	Variance - Males	Variance - Females	DF	F	P-Non-Directional
Conservation of Substance					
(Conservation Score)	6.41	6.41	51	1.001	0.999
(Explanation Score)	6.23	6.67	51	1.070	0.810
Conservation of Continuous Quantity					
(Conservation Score)	6.23	6.45	51	1.035	0.902
(Explanation Score)	6.49	6.22	51	1.044	0.879
Conservation of Discontinuous Quantity					
(Conservation Score)	6.23	6.23	51	1.000	1.000
(Explanation Score)	6.40	6.43	51	1.005	0.987
Conservation of Weight					
(Conservation Score)	7.35	7.21	51	1.019	0.946
(Explanation Score)	7.28	7.89	51	1.084	0.774
Conservation of Area					
(Conservation Score)	4.78	8.52	51	1.782	0.051
(Explanation Score)	7.05	9.22	51	1.307	0.343
Conservation of Volume					
(Conservation Score)	5.22	5.89	51	1.129	0.667
(Explanation Score)	4.93	4.51	51	1.092	0.754
Conservation of Density					
(Conservation Score)	7.39	8.87	51	1.200	0.518
(Explanation Score)	8.31	10.09	51	1.213	0.492
Formal Operations Question	0.97	0.95	51	1.021	0.942

TABLE 20

INTERCORRELATIONS OF ALL PIAGETIAN TASKS
(COMBINING CONSERVATION AND EXPLANATION SCORES FOR EACH TASK)

	Substance	Continuous Quantity	Discontinuous Quantity	Weight	Area	Volume	Density	Formal Operations Question
Conservation of Substance		.865*	.871**	.769**	.767**	.260**	.354**	.374**
Conservation of Continuous Quantity			.981**	.803**	.745**	.268**	.379**	.386**
Conservation of Discontinuous Quantity				.799**	.737**	.279**	.366**	.380**
Conservation of Weight					.609**	.242*	.314**	.324**
Conservation of Area						.267**	.306**	.318**
Conservation of Volume							.255**	.231*
Conservation of Density								.326**

*Significant at the .05 level.
**Significant at the .01 level.

TABLE 21

INTERCORRELATIONS OF ALL PIAGETIAN SCORES WITH TOTAL PIAGETIAN SCORES

	Concrete Operations, Conservation	Concrete Operations, Explanation	Concrete Operations, Total	Formal Operations, Conservation	Formal Operations, Explanation	Formal Operations, Total	Total Conservation	Total Explanation	Grand Total
Conservation of Substance	.885**	.906**	.900**	.353**	.450**	.414**	.854**1	.893**	.883**
Conservation of Continuous Quantity	.939**	.923**	.935**	.386**	.466**	.441**	.911**	.913**	.921**
Conservation of Discontinuous Quantity	.933**	.924**	.933**	.384**	.461**	.437**	.904**	.911**	.917**
Conservation of Weight	.856**	.865**	.865**	.344**	.380**	.375**	.825**	.840**	.842**
Conservation of Area	.824**	.823**	.828**	.324**	.417**	.383**	.794**	.810**	.810**
Conservation of Volume	.439**	.442**	.443**	.711**	.700**	.732**	.452**	.436**	.446**
Conservation of Density	.399**	.391**	.398**	.782**	.806**	.823**	.568**	.536**	.553**
Formal Operations Question	.401**	.391**	.399**	.492**	.383**	.456**	.486**	.426**	.457**
Total Conservation Score for Concrete Operations Tasks		.970**	.985**	.491**	.565**	.547**	.962**	.956**	.968**
Total Explanation Score for Concrete Operations Tasks			.985**	.481**	.566**	.541**	.940**	.973**	.966**
Total Score for Concrete Operations Tasks				.490**	.570**	.548**	.956**	.969**	.973**
Total Conservation Score for Formal Operations Tasks					.851**	.957**	.637**	.559**	.599**
Total Explanation Score for Formal Operations Tasks						.952**	.665**	.674**	.672**
Total Score for Formal Operations Tasks							.675**	.637**	.658**
Total Conservation Score								.957**	.980**
Total Explanation Score									.983**
Grand Total									

**Significant at .01 level.

although the most difficult tasks tend to have the lowest intercorrelations with other areas. It was expected that the conservation tasks would show definite relationship, in spite of the differing methods of assessing each area, but it is interesting to note that the Formal Operations Question correlated about as well as the other formal level conservation problems. These results are in keeping with those of Goldschmid. Table 22 illustrates the correlations between Piagetian scores and age, all of which are highly significant, as would be expected on the basis of Piaget's theory.

Stepwise regression was also performed on the Piagetian tasks to discern which measures best predicted mental age (Table 23). Three tasks emerged as significant discriminators at the .01 level, as did one task at the .05 level. All were difficult formal operations level problems except the very best predictor, which was Conservation of Discontinuous Quantity. This variable accounted for 54 per cent of the total variance. Its success as a predictor may be related to its intermediate level of difficulty, as the easiest tasks were among the poorest predictors of age, although the relationship was by no means clear cut.

The actual relative difficulty of the various Piagetian tasks is contained in Table 24. The distribution for each problem was normalized to permit comparison of mean scores by ranking from least difficult to most difficult.

TABLE 22

INTERCORRELATIONS OF PIAGETIAN SCORES WITH AGE

Variable	
Conservation of Substance	.709**
Conservation of Continuous Quantity	.737**
Conservation of Discontinuous Quantity	.740**
Conservation of Weight	.628**
Conservation of Area	.615**
Conservation of Volume	.392**
Conservation of Density	.478**
Formal Operations Question	.488**
Total Conservation Score for Concrete Operations Tasks	.756**
Total Explanation Score for Concrete Operations Tasks	.773**
Total Score for Concrete Operations Tasks	.770**
Total Conservation Score for Formal Operations Tasks	.497**
Total Explanations Score for Formal Operations Tasks	.636**
Total Score for Formal Operations Tasks	.586**
Total Conservation Score	.773**
Total Explanation Score	.803**
Grand Total	.792**

**Significant at .01 level.

TABLE 23

STEP-WISE REGRESSION PREDICTING AGE FROM EIGHT PIAGETIAN TASKS

	F-Value	Probability Level	% of Variance Accounted for	% of Total Variance Accounted for	Standard Error of Predicted Y
Conservation of Discontinuous Quantity	123.455728	0.000000**	54.758302	54.758302	2.541266
Formal Operations Question	12.289770	0.000681**	4.907857	59.666159	2.411320
Conservation of Density	8.303386	0.004843**	3.092304	62.758468	2.328598
Conservation of Volume	5.318231	0.023188*	1.898604	64.657072	2.279892
Conservation of Substance	2.390999	0.125259	.841758	65.498830	2.264042
Conservation of Area	0.313051	0.577106	.110989	65.609819	2.272019
Conservation of Weight	0.099704	0.752871	.035680	65.645499	2.282637
Conservation of Continuous Quantity	0.018961	0.890771	.006855	65.652354	2.294391

*Significant at .05 level.
**Significant at .01 level.

TABLE 24

DIFFICULTY LEVEL OF ALL PIAGETIAN TASKS,
BASED ON NORMALIZED DISTRIBUTION FROM LEAST DIFFICULT TO MOST DIFFICULT

Rank	Task	Transformed Mean	Transformed Standard Deviation	Original Mean	Original Standard Deviation
1	Conservation of Area	49.53	6.84	13.45	5.16
2	Conservation of Continuous Quantity	49.46	6.78	9.17	4.90
3	Conservation of Discontinuous Quantity	49.48	7.01	9.08	4.87
4	Conservation of Substance	49.54	7.20	8.76	4.96
5	Conservation of Weight	49.64	6.92	8.07	5.37
6	Conservation of Density	50.20	8.17	7.17	5.38
7	Formal Operations Question	50.27	6.66	0.75	0.97
8	Conservation of Volume	50.61	6.80	2.45	4.47

Present results vary from those of Goldschmid, who found Substance to be the easiest conservation, followed by Continuous Quantity, Discontinuous Quantity, Weight and Area. Here Conservation of Area emerged as least difficult; whereas Substance rated fourth, following the Quantity problems. The contrast is particulary puzzling in view of the similarity of experimental procedures. Present results confirm those of Piaget (1965), Elkind (1961), Smedslund (1961), Uzigris (1964) and Papalia (1972) who found that Conservation of Substance develops before Conservation of Weight, and Weight before Volume. Goldschmid also found Continuous Quantity to be easier than Discontinuous Quantity, although Elkind (1961) disagrees. Thus, H_5 is rejected.

The difficulty level of the Piagetian problems was further explored using Guttman's Scalogram Analysis, in the manner of Uzigris (1964). Table 25 contains the scale-type matrix for Piagetian success based on the conservation or initial judgement scores only, Table 26 illustrates the matrix when explanation of the conservation phenomenon is included in the success criteria. Table 24 reveals a very similar estimation of task difficulty to that obtained by normalizing the data, with the exception that here Conservation of Continuous Quantity emerged as equally difficult as the discontinuous problems. The explanation based matrix also suggests continuous conservation is

TABLE 25

SCALE-TYPE MATRIX FOR GUTTMAN SCALING USING THE GOODENOUGH TECHNIQUE ON PIAGETIAN SUCCESSES (EXPLANATION NOT CONSIDERED)

Item		Volume		Formal Question		Density		Weight		Substance		Continuous Quantity		Discontinuous Quantity		Area		
Cat.		0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	
SCALE TYPE	8	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	6
	7	14	11	7	18	3	22	1	24	0	25	0	25	0	25	0	25	25
	6	18	2	10	10	10	10	2	18	0	20	0	20	0	20	0	20	20
	5	23	0	21	2	22	1	2	21	0	23	0	23	0	23	1	22	23
	4	4	0	4	0	3	1	3	1	1	3	0	4	0	4	1	3	4
	3	4	1	4	1	5	0	4	1	4	1	2	3	2	3	0	5	5
	2	2	1	3	0	3	0	3	0	1	2	3	0	3	0	0	3	3
	1	9	0	9	0	4	5	9	0	9	0	9	0	9	0	5	4	9
	0	9	0	9	0	9	0	9	0	9	0	9	0	9	0	9	0	9
Sum		83	21	67	37	59	45	33	71	24	80	23	81	23	81	16	88	104
P		0.20		0.36		0.43		0.68		0.77		0.78		0.78		0.85		
Q			0.80		0.64		0.57		0.32		0.23		0.22		0.22		0.15	
Error		0	15	7	13	13	7	5	2	1	3	2	0	5	0	7	0	80

Coefficient of Reproducibility = 0.9038

TABLE 26

SCALE-TYPE MATRIX FOR GUTTMAN SCALING USING THE GOODENOUGH TECHNIQUE
ON PIAGETIAN SUCCESSES (EXPLANATION CONSIDERED)

Item		Volume		Density		Formal Question		Weight		Substance		Continuous Quantity		Discontinuous Quantity		Area		
Cat.		0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	
SCALE TYPE	8	0	3	0	3	0	3	0	3	0	3	0	3	0	3	0	3	3
	7	8	9	5	12	3	14	1	16	0	17	0	17	0	17	0	17	17
	6	20	4	17	7	9	15	2	22	0	24	0	24	0	24	0	24	24
	5	29	0	28	1	25	4	2	27	2	27	0	29	0	29	1	28	29
	4	2	0	2	0	2	0	2	0	0	2	0	2	0	2	0	2	2
	3	3	0	3	0	3	0	2	1	2	1	1	2	1	2	0	3	3
	2	3	1	4	0	4	0	4	0	2	2	3	1	3	1	1	3	4
	1	3	0	3	0	3	0	3	0	3	0	3	0	3	0	0	3	3
	0	19	0	19	0	19	0	19	0	19	0	19	0	19	0	19	0	19
Sum		87	17	81	23	67	36	35	69	28	76	26	78	26	78	21	83	104
P		0.16		0.22		0.36		0.66		0.73		0.75		0.75		0.80		
Q			0.84		0.78		0.64		0.34		0.27		0.25		0.25		0.20	
Error		0	14	5	8	12	4	5	1	2	3	1	1	4	0	2	0	62

Coefficient of Reproducibility = 0.9255

equally as challenging as the discontinuous tasks, but also ranks the Formal Operations Question prior to the Conservation of Density. This discrepancy suggests that children can more easily guess whether an object will sink or float than perform the reasoning required to answer the Formal Operations Question, but find explaining Conservation of Density more difficult than answering the Formal Question. The total number of children passing and failing each Piagetian task on the basis of each criterion is located in the "Sums" row of each Scalogram matrix. Comparing these values reveals that there is the greatest discrepancy between success level for conservation of density, as 67 children were able to predict correctly, but only 23 were able to explain their answers satisfactorily. The difference in difficulty level of the quantity problems for the scalogram and normalizing methods can be attributed to the fact that the latter is based on raw scores, where the former analysis requires an estimation of only task success or failure. The normalized estimation for both problems is extremely close (49.46 and 49.48). Thus, it seems reasonable to consider the two areas to be of equal difficulty, as the scalogram technique suggests.

Although scalogram analysis was undertaken primarily to compare the difficulty level of the various tasks, each matrix did form a very good and genuine scale. This suggests that a child passing a given item tended also to

pass all easier items and to fail all more difficult ones. Of course the pattern is not perfect in either case, but the obtained coefficients of reproducibility of .90 for the estimation scores and .93 for the explanation criteria are within the 10 per cent error range, which is considered the minimal estimate of scalability (Torgerson, 1958). A coefficient of .90 or better is usually considered the necessary criterion, thus the explanation scores form a slightly superior scale to the conservation or judgement scores. This suggests that perhaps requiring the subject to explain his answer is a somewhat more valid criterion of conservation than merely basing his ability to conserve on his initial judgements. The question of appropriate criteria for evidence of conservation ability has been much discussed by various investigators, but Piaget has held steadfastly to the position that if explanation is not required, conservation is not being properly investigated (1972). Thus, the scalogram results support Piaget's position as regards several aspects of his theory. The fact that his tasks form a scale bears out his invariant sequence idea, and the level of slight error involved reveals the existence of some decalage.

Piaget also maintains that the conservation problems in the realm of formal operations are much more difficult than those at the concrete level, as does Brainerd (1970, 1971). Table 24 clearly illustrates that this is in fact

the case, as between 16 and 33 of a total N of 104 children failed the first tasks. Conversly, 59 failed the Density problem, 67 the Formal Question, and 83 the Volume problem on the basis of initial judgements. On Table 26, between 25 and 35 failed Density, and 87 Volume. In terms of percentages, between 65% and 85% of the total sample made correct conservation judgements on the five concrete level tasks, but only 43%, 36% and 20% were successful on Density, the Formal Question, and Volume respectively. Where explanations were required, 66% to 80% passed the concrete tasks, but only 36% were correct on the Formal Question, 22% on Conservation of Density and 16% on Volume.

The percentages of subjects at each age level who were successful in each task area are reported in Tables 27 and 28. Piaget judges attainment of conservation to occur at the age at which the majority of the children succeed. On this basis, the children in the present study made successful conservation judgments at age 7 for problems involving Substance, Quantity (continuous or discontinuous) and Weight. Fifty percent of the 6 year olds conserved area, with 100% success occurring at age 7 and beyond. The majority of the sample could make correct density judgements at 10 years, and the Formal Operations Question was successfully answered at 11 years. Conservation of Volume never exceeded the 50% level at any age, and only reached this amount at age 15 and 16. Identical ages of attainment

TABLE 27

PERCENTAGE OF SUBJECTS PASSING EACH PIAGETIAN TASK
(EXPLANATION NOT CONSIDERED)

Age (Years)	Substance %	Continuous Quantity %	Discontinuous Quantity %	Weight %	Area %	Volume %	Density %	Formal Operations Question %
4	0.0	0.0	0.0	0.0	25.0	0.0	37.5	12.5
5	0.0	12.5	12.5	0.0	37.5	12.5	25.0	0.0
6	37.5	25.0	25.0	25.0	50.0	0.0	20.0	0.0
7	87.5	75.0	75.0	75.0	100.0	0.0	25.0	20.0
8	87.5	100.0	100.0	62.5	100.0	25.0	20.0	40.0
9	100.0	100.0	100.0	100.0	100.0	25.0	43.0	29.0
10	87.5	100.0	100.0	75.0	100.0	0.0	71.0	29.0
11	100.0	100.0	100.0	87.5	87.5	12.5	25.0	62.5
12	100.0	100.0	100.0	100.0	100.0	25.0	71.0	86.0
13	100.0	100.0	100.0	100.0	100.0	25.0	75.0	75.0
14	100.0	100.0	100.0	100.0	100.0	25.0	62.5	50.0
15	100.0	100.0	100.0	75.0	100.0	50.0	75.0	50.0
16	100.0	100.0	100.0	87.5	100.0	50.0	62.5	75.0

TABLE 24

DIFFICULTY LEVEL OF ALL PIAGETIAN TASKS,
BASED ON NORMALIZED DISTRIBUTION FROM LEAST DIFFICULT TO MOST DIFFICULT

Rank	Task	Transformed Mean	Transformed Standard Deviation	Original Mean	Original Standard Deviation
1	Conservation of Area	49.53	6.84	13.45	5.16
2	Conservation of Continuous Quantity	49.46	6.78	9.17	4.90
3	Conservation of Discontinuous Quantity	49.48	7.01	9.08	4.87
4	Conservation of Substance	49.54	7.20	8.76	4.96
5	Conservation of Weight	49.64	6.92	8.07	5.37
6	Conservation of Density	50.20	8.17	7.17	5.38
7	Formal Operations Question	50.27	6.66	0.75	0.97
8	Conservation of Volume	50.61	6.80	2.45	4.47

were found for all five concrete level tasks when explanation was used as a criterion, although the actual number of successes was often slightly lower. Volume results were exactly the same for both criteria, with conservation attainment again emerging at age 15. Cnly Conservation of Density yielded different ages of attainment depending on the criterion employed, as success did not reach the 50% level until age 15 when explanation was required. This is a full five years later than the age of attainment of reliable density judgements.

Although the scalogram analysis suggests there is a definite heirarchy of difficulty for the various Piagetian conservations, and that there is a reliable sequence of attainment; in terms of chronclogical and mental age, all concrete conservations appear to be attained at about 7 years. The problems considered to be of the Formal Operations type are solved much later - the Formal Operations Questicn at age 11, and Conservation of Density and Volume at 15 years - if Piaget's preferred explanation criteria is adopted for Density. This pattern supports the appropriateness of the concrete formal distinction and attests to the validity of the developmental stage model in general, however a few of these age estimates differ slightly from those proposed by Piaget. Piaget and several other investigators found Conservation of Weight did not appear until about 9 years of age (Elkind, 1961; Lovell and

Ogilvie, 1960, 1961a; Piaget and Inhelder, 1941, 1947; Smedslund, 1961b,c,d). Piaget suggests that Conservation of Volume and Density are acquired at about 11 or 12 years, although Brainerd interprets his position on the matter in terms of between 11 and 15 years. Present findings indicate that these conservations are not a reality before 15 years, which is in keeping with the research of Elkind (1961), Papalia (1972) and Uzigris (1964). Papalia discovered that peak Volume Conservation was not reached until well past adolescence.

Two unexpected findings occurred in connection with ages and order of conservation attainment: the ease with which children solved the Conservation of Area problem, and the fact that Conservation of Weight was acquired two years earlier than expected. A number of quite young children spontaneously mentioned weight even in connection with the Substance problem i.e. "they are the same because you didn't take any away, and they would weigh the same", which suggests they are well aware of this concept. Those who solved the Area task usually succeeded by counting the blocks, which raises the possibility that the Barns and Cows problem may be more closely related to Conservation of Number than to the Area concept. If this is a legitimate comparison, then these findings are not so puzzling.

As mentioned in the review of the literature section, several recent studies have purported to find Conservation

of Number in very young children. These claims have largely been criticized by Piaget; however, there seems to be little doubt that children are learning to count and being made aware of other related numerical concepts at an earlier age thanks to exposure to pre-school televised instruction. It is difficult to know if this would affect age of conservation attainment, but it seems a plausible hypothesis, (at least in terms of the slightly younger ages found here as opposed to the extravagent claims of some researchers). Although specific kinds of instruction have not been found to affect conservation, early "general life experiences" have. Perhaps repeated exposure to numerical-type concepts at a very young age have a subtle enough and consistent enough influence to become assimilated and accommodated into everyday happenings.

In 1967 Goldschmid found Conservation of Number to be just slightly more difficult than Conservation of Substance, with the Area problems ranking as much more challenging. However, Goldschmid did not test children aged 4 to 6. Is it possible that children of this age are unusually "counting oriented" due to parental and televised expectations? Is it also possible that the slightly older subjects in the present sample had a similar bias due to these types of early influences? Perhaps the present sample viewed the "Cow and Barns" task in terms of numbers, while those who were aged 7 in 1967 considered the problem more in

terms of area due to differing general early experiences.

In view of the fact that present results consistently support the idea that performance on the present battery genuinely reflects cognitive stages, each subject was assigned to a stage level on the basis of his test scores. Table 29 shows the percentage of subjects at each age who placed within each major Piagetian stage on the basis of the conservation, or initial judgement scores. The Pre-operational Stage includes age 4, 5, and 6; the Stage of Concrete Operations emerges at 7 years and continues until age 12, and the Formal Operations Stage gains majority at age 13 and is solidly established at 15 and 16 years of age. When explanations of conservation are considered (Table 30), a similar pattern is observed, with the exception that Formal Operations does not reach the fifty per cent level until 15 years and does not gain majority until age 16. This is in keeping with Piaget's theoretical model, except that the Stage of Formal Operations is reached somewhat later than he predicts. Here, as with the Vygotsky data, it is interesting to note that all subjects at even the oldest age level do not necessarily attain the highest levels of thought.

Analysis of variance could not be used to statistically analyze the difference in performance between age levels, as all Piagetian variables contained instances of zero variance. Thus t tests between adjacent ages were

TABLE 29

PERCENTAGE OF SUBJECTS FALLING AT EACH PIAGETIAN STAGE, ON THE BASIS OF CONSERVATION SCORES

Age	Pre-operational Stage %	Concrete Operational Stage %	Formal Operational Stage %
4 years	100		
5 years	100		
6 years	87.5	12.5	
7 years	25	75	
8 years	12.5	62.5	25
9 years		62.5	37.5
10 years	12.5	62.5	25
11 years		75	25
12 years		62.5	37.5
13 years		37.5	62.5
14 years		62.5	37.5
15 years		25	75
16 years		25	75

TABLE 30

PERCENTAGE OF SUBJECTS FALLING AT EACH PIAGETIAN STAGE, ON THE BASIS OF EXPLANATION SCORES

Age	Pre-operational Stage %	Concrete Operational Stage %	Formal Operational Stage %
4 years	100		
5 years	100		
6 years	87.5	12.5	
7 years	37.5	62.5	
8 years	25	75	
9 years		75	25
10 years	12.5	87.5	
11 years		75	25
12 years		75	25
13 years		62.5	37.5
14 years		62.5	37.5
15 years		50	50
16 years		25	75

employed for this purpose. The data regarding significant t tests only is included in Table 31, with the individual mean and standard deviations for all Piagetian scores reported in Tables 32-35. Graphic illustrations of the means for each age level (with significant differences indicated) are found in Figures 15-27. A similar pattern is observed for Substance, Continuous Quantity, Discontinuous Quantity, Weight, and Area, as each of these tasks yield a significant difference between 6 and 7 years of age. This suggests that the performance of the 4, 5, and 6 year olds differed from those of all other ages. This is exactly as would be expected on the basis of Piaget's theoretical model, as all five of these tasks have been assumed to distinguish between the Pre-operational and the Concrete Operational Stages. The transition from one stage to another is expected to occur at about 7 years of age, which was exactly verified by these t tests. Conservation of Density also showed this distinction at 7 years, but the scores of the 10 year olds were found to be significantly lower than the 11's as well. Performance on this task is clearly erratic in the extreme at the lower ages, as the lowest means occur at 6 and 10 years, yet ages 4, 7 and 9 do relatively well. This instability is probably a reflection of the aforementioned discrepancy between initial conservation judgements and the ability to explain the phenomenon. Thus the scores of some age levels may be inflated on the basis of their superior

TABLE 31

SUMMARY OF SIGNIFICANT T TESTS BETWEEN AGE LEVELS ON THE PIAGETIAN TASKS

Age	Variable	$\bar{X}$ 1	$\bar{X}$ 2	T	P-One Tail	P-Two Tail	F-test for Differences of Variance	P-Non-Directional	Welch T' Adjustment	P-One Tail	P-Two Tail
Age 6 vs. 7											
	Conservation of Substance	3.12	10.00	-3.059	0.004	0.008	1.21	0.808			
	Conservation of Continuous Quantity	2.37	8.87	-2.796	0.007	0.014	1.047	0.953			
	Conservation of Discontinuous Quantity	2.62	8.87	-2.595	0.011	0.022	1.097	0.906			
	Conservation of Weight	2.62	7.75	-2.113	0.026	0.053	1.460	0.630			
	Conservation of Area	7.50	15.00	-2.546	0.012	0.023	19.25	0.0009	-2.685	0.009	0.018
	Conservation of Density	2.50	5.62	-2.685	0.009	0.017	1.71	0.496			
	Total S Scores for Concrete Conservation Tasks	10.00	26.00	-3.121	0.004	0.008	1.706	0.498			
	Total Explanation Scores for Concrete Conservation Tasks	8.50	25.00	-3.414	0.002	0.004	1.555	0.575			
	Total S Scores for Concrete Conservation Tasks	18.25	51.00	-3.358	0.002	0.004	1.541	0.582			
	Total S Scores for Formal Tasks	2.50	4.62	-1.802	0.046	0.093	1.781	0.464			
	Total Scores for Formal Tasks	2.50	6.37	-2.353	0.017	0.034	4.424	0.068			
	Total S Scores	12.50	28.87	-2.922	0.005	0.011	1.576	0.563			
	Total Explanation Scores	8.50	26.50	-3.658	0.001	0.002	1.421	0.654			
	Grand Total	21.00	56.63	-3.417	0.002	0.004	1.500	0.605			
Age 8 vs. 9											
	Total Explanation Scores	27.87	34.75	-2.177	0.0235	0.047	1.312	0.729			
	Grand Total	60.87	72.75	-1.983	0.033	0.673	1.694	0.503			
Age 10 vs. 11											
	Conservation of Density	9.25	4.25	1.902	0.039	0.078	1.132	0.874			
Age 11 vs. 12											
	Total S Scores for Formal Tasks	5.00	9.25	-2.055	0.029	0.059	1.737	0.483			
	Total Score for Formal Tasks	7.50	14.37	-1.970	0.034	0.068	1.819	0.448			
	Total S Scores	35.75	40.88	-2.220	0.022	0.044	1.900	0.416			
	Total Explanation Scores	32.35	36.63	-2.221	0.022	0.044	1.592	0.555			
	Grand Total	68.00	77.50	-2.316	0.018	0.036	1.837	0.440			

TABLE 32

MEANS AND STANDARD DEVIATIONS FOR PIAGETIAN TASKS (CONSERVATION SCORES)

Variable	Age	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Conservation of Substance	M	0.0	0.0	1.750	5.00	5.00	5.750	5.250	6.0	6.0	6.0	6.0	6.0	5.75	4.50
	SD	0.0	0.0	2.493	2.138	2.138	0.707	2.121	0.0	0.0	0.0	0.0	0.0	0.707	2.508
Conservation of Continuous Quantities	M	0.0	0.750	1.250	4.50	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	4.654
	SD	0.0	2.121	2.376	2.330	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.456
Conservation of Discontinuous Quantities	M	0.0	0.750	1.50	4.50	5.750	5.750	6.0	6.0	6.0	6.0	6.0	6.0	6.0	4.635
	SD	0.0	2.121	2.778	2.330	0.707	0.707	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.454
Conservation of Weight	M	0.0	0.0	1.50	4.0	3.750	6.0	4.75	5.250	6.0	6.0	6.0	4.50	5.250	4.077
	SD	0.0	0.0	2.330	2.617	2.712	0.0	2.376	1.488	0.0	0.0	0.0	2.778	2.121	2.674
Conservation of Area	M	3.250	3.750	3.750	7.50	7.750	7.750	8.0	7.75	8.0	8.0	8.0	8.0	8.0	6.885
	SD	3.012	3.770	4.062	0.926	0.707	0.707	0.0	0.707	0.0	0.0	0.0	0.0	0.0	2.478
Conservation of Volume	M	0.0	0.50	0.0	0.50	1.25	1.50	0.50	1.0	1.750	1.750	1.50	3.0	3.250	1.269
	SD	0.0	1.414	0.0	0.926	2.376	2.778	0.926	2.138	2.712	2.712	2.778	3.207	3.012	2.288
Conservation of Density	M	4.50	3.250	2.50	3.875	3.750	4.750	5.50	2.750	6.0	5.50	5.50	6.0	6.0	4.606
	SD	2.976	2.816	2.0	1.885	2.252	2.375	2.778	3.012	2.828	2.976	3.162	2.828	3.024	2.816
Formal Operations Question	M	0.250	0.0	0.0	0.250	0.50	0.50	0.5	1.250	1.50	1.50	1.0	1.0	1.50	0.750
	SD	0.707	0.0	0.0	0.707	0.926	0.926	0.926	1.035	0.926	0.926	1.069	1.069	0.926	0.968

TABLE 33

MEANS AND STANDARD DEVIATIONS FOR PIAGETIAN TASKS (EXPLANATION SCORES)

Variable	Age	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Conservation of Substance	M	0.0	0.0	1.375	5.0	4.75	4.75	5.25	6.0	5.5	5.5	6.00	5.75	5.5	4.260
	SD	0.0	0.0	2.326	2.138	2.121	2.121	2.121	0.0	0.926	0.926	0.0	0.707	0.926	2.523
Conservation of Continuous Quantities	M	0.0	0.0	1.125	4.375	5.50	6.00	6.00	6.00	6.00	6.00	6.00	6.00	5.75	4.519
	SD	0.0	0.0	2.232	2.387	0.756	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.707	2.488
Conservation of Discontinuous	M	0.0	0.0	1.125	4.375	5.625	5.625	5.50	5.75	6.00	6.00	6.00	6.00	5.75	4.442
	SD	0.0	0.0	2.232	2.836	0.744	0.744	1.069	0.707	0.0	0.0	0.0	0.0	0.707	2.476
Conservation of Weight	M	0.0	0.0	1.125	3.75	3.75	6.00	4.625	5.125	6.00	6.00	6.00	4.50	5.00	3.990
	SD	0.0	0.0	2.100	2.712	2.712	0.0	2.560	1.808	0.0	0.0	0.0	2.778	2.138	2.709
Conservation of Area	M	1.25	2.625	3.75	7.50	7.50	7.75	8.0	7.125	8.0	8.0	8.0	8.0	7.875	6.567
	SD	1.832	3.583	4.062	0.926	1.414	0.707	0.0	1.808	0.0	0.0	0.0	0.0	0.354	2.797
Conservation of Volume	M	0.0	0.50	0.0	0.25	0.625	1.50	0.50	1.0	1.75	1.75	1.50	2.750	3.25	1.183
	SD	0.0	1.414	0.0	0.707	1.188	2.778	0.926	2.138	2.712	2.712	2.778	3.012	3.012	2.200
Conservation of Density	M	0.0	0.125	0.0	1.750	1.250	3.125	3.750	1.50	3.375	3.375	4.875	5.0	5.25	2.567
	SD	0.0	0.354	0.0	0.886	1.035	3.227	2.866	2.138	3.021	3.204	3.523	3.338	3.370	2.957

TABLE 34

MEANS AND STANDARD DEVIATIONS FOR PIAGETIAN TASKS (CONSERVATION PLUS EXPLANATION SCORES)

Variable	Age	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Conservation of Substance	M	0.0	0.0	3.125	10.0	9.750	10.50	10.500	12.000	11.50	11.50	12.00	11.75	11.25	8.760
	SD	0.0	0.0	4.704	4.276	4.200	2.330	4.243	0.0	0.926	0.926	0.0	0.707	1.488	4.962
Conservation of Continuous Quantities	M	0.0	0.75	2.375	8.875	11.50	12.00	12.00	12.00	12.00	12.00	12.00	12.00	11.75	9.173
	SD	0.0	2.121	4.596	4.704	0.756	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.707	4.900
Conservation of Discontinuous Quantities	M	0.0	0.75	2.625	8.875	11.375	11.375	11.50	11.75	12.00	12.00	12.00	12.00	11.75	9.077
	SD	0.0	2.121	4.926	4.704	1.408	1.408	1.069	0.707	0.0	0.0	0.0	0.0	0.707	4.869
Conservation of Weight	M	0.0	0.0	2.625	7.75	7.75	12.00	9.375	10.375	12.00	12.00	12.00	9.00	10.25	8.067
	SD	0.0	0.0	4.373	5.285	5.425	0.0	4.926	3.293	0.0	0.0	0.0	5.555	4.20	5.370
Conservation of Area	M	4.5	6.375	7.5	15.00	15.25	15.5	16.00	14.875	16.00	16.00	16.00	16.00	15.875	13.452
	SD	4.629	6.802	8.124	1.852	2.121	1.414	0.0	2.100	0.0	0.0	0.0	0.0	0.354	5.155
Conservation of Volume	M	0.0	1.00	0.0	0.75	1.875	3.00	1.00	2.00	3.50	3.50	3.00	5.75	6.50	2.452
	SD	0.0	2.828	0.0	1.488	3.563	5.555	1.852	4.276	5.425	5.425	5.555	6.182	6.024	4.468
Conservation of Density	M	4.50	3.375	2.500	5.625	5.00	7.875	2.250	4.250	9.375	8.875	10.375	11.00	11.250	7.173
	SD	2.976	2.774	2.00	2.615	2.619	5.489	5.418	5.092	5.236	5.768	6.632	6.024	6.319	5.379
Formal Operations Question	M	0.250	0.0	0.0	0.250	0.500	0.500	0.500	1.250	1.50	1.50	1.00	1.00	1.50	0.750
	SD	0.707	0.0	0.0	0.707	0.926	0.926	0.926	1.035	0.926	0.926	1.069	1.069	0.926	0.968

TABLE 35

MEANS AND STANDARD DEVIATIONS FOR TOTAL PIAGETIAN SCORES

Variable	Age	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Total Conservation Score for Concrete Operations Tasks	M	3.250	6.0	10.0	26.0	28.75	32.75	30.5	31.75	33.50	33.750	33.50	33.250	34.250	25.942
	SD	3.012	7.329	11.514	8.816	6.319	3.370	4.629	3.105	2.778	2.712	2.778	4.400	2.712	12.176
Total Explanation Score for Concrete Operations Tasks	M	1.250	3.250	8.50	25.0	26.625	31.625	29.875	30.750	33.0	33.250	33.50	32.750	33.125	24.808
	SD	1.832	4.743	10.664	8.553	7.347	4.207	5.027	3.328	3.207	3.196	2.778	3.991	4.257	12.642
Total Score (C + E) for the Concrete Operations Tasks	M	4.50	9.250	18.250	51.0	55.25	64.375	60.375	62.50	66.50	67.0	67.0	66.0	67.375	50.721
	SD	4.629	10.181	21.479	17.304	13.615	7.328	9.561	6.325	5.928	5.855	5.555	8.281	6.391	24.686
Total Conservation Score for Formal Operations Tasks	M	4.750	3.750	2.50	4.625	5.50	6.750	6.50	5.0	9.250	8.50	8.0	10.0	10.75	6.606
	SD	3.370	3.284	2.0	2.669	4.106	4.400	2.564	4.659	3.536	4.870	3.024	4.660	5.946	4.408
Total Explanation Score for Formal Operations Tasks	M	0.0	0.625	0.0	1.750	1.875	4.625	4.250	2.50	5.125	5.125	6.375	7.750	8.750	3.750
	SD	0.0	1.408	0.0	1.581	0.835	4.955	2.435	3.295	2.850	5.249	4.182	3.412	5.445	4.139
Total Score for the Formal Operations Tasks	M	4.75	4.375	2.50	6.375	7.375	11.375	10.750	7.50	14.375	13.625	14.375	17.750	19.50	10.356
	SD	3.370	4.138	2.0	4.207	4.809	9.226	4.432	7.928	5.878	9.841	7.090	8.013	11.352	8.242
Total Conservation Score	M	7.750	9.0	12.50	28.875	33.0	38.0	36.50	36.750	40.875	40.50	40.0	39.50	41.750	31.077
	SD	3.919	8.485	12.398	9.877	7.251	4.899	5.632	5.285	3.834	4.870	3,024	5,099	5.497	13.700
Total Explanation Score	M	1.250	3.375	8.50	26.50	27.875	34.750	33.625	32.250	36.625	36.625	38.375	37.00	38.375	27.317
	SD	1.832	4.926	10.664	8.944	6.728	5.874	5.209	4.367	3.462	5.706	4.138	4.175	5.125	14.237
Grand Total	M	9.0	12.375	21.0	56.625	60.875	72.750	70.125	68.0	77.50	77.125	78.375	76.50	80.125	58.490
	SD	5.345	11.439	22.841	18.647	13.432	10.340	10.629	9.335	6.887	10.176	7.090	9.103	10.092	27.708

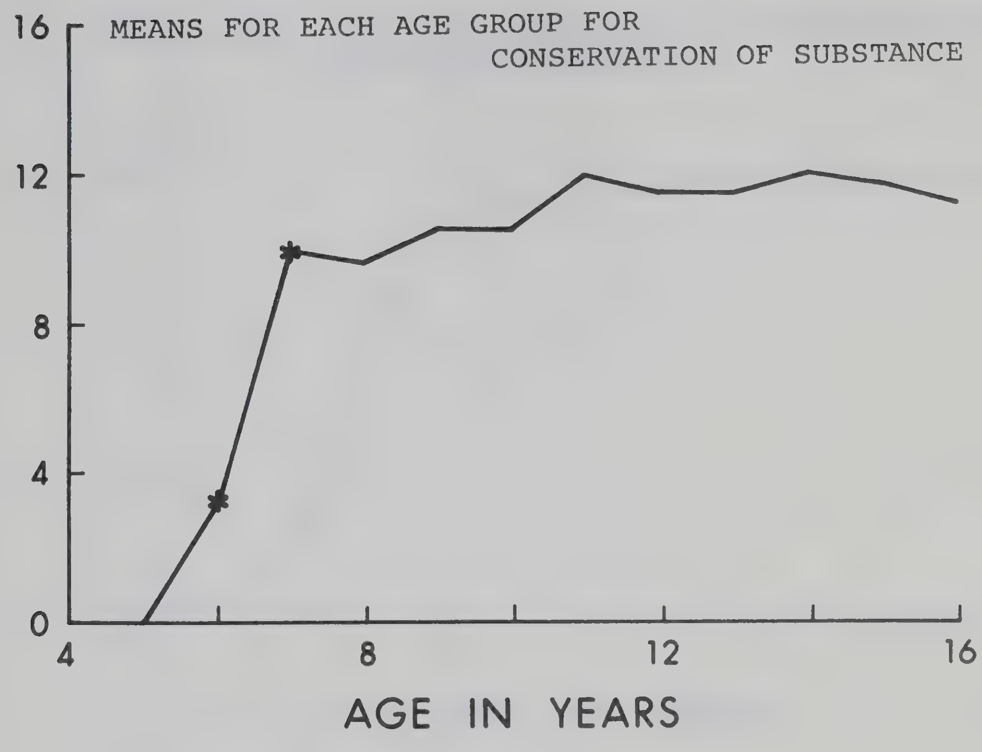
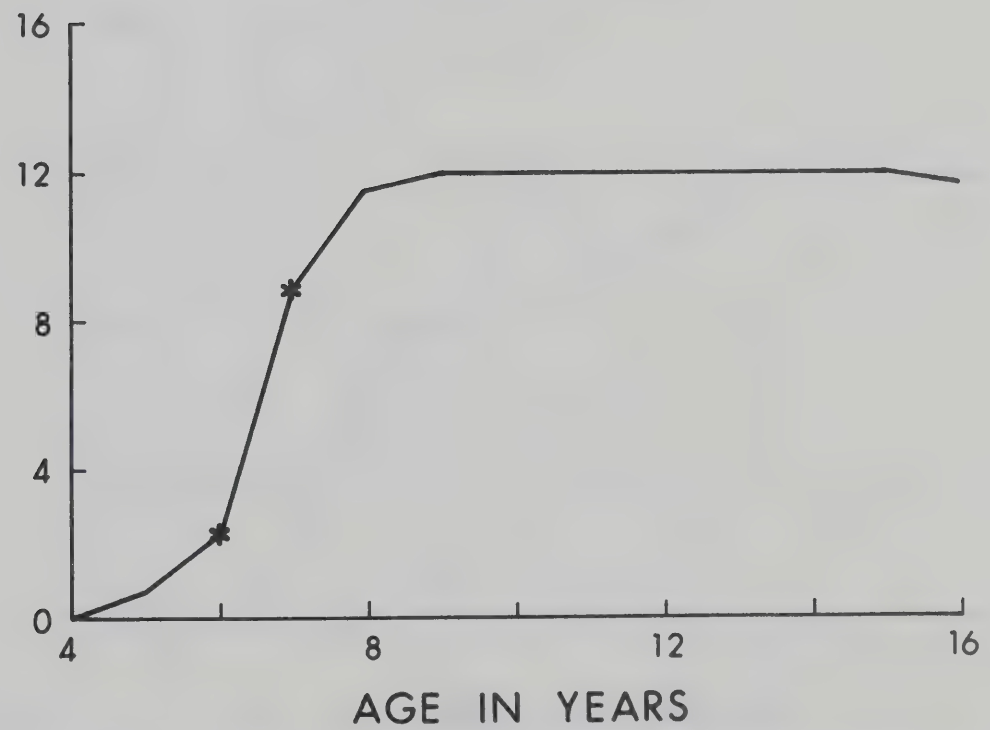


Figure 15.



MEANS FOR EACH AGE GROUP FOR CONSERVATION OF CONTINUOUS QUANTITY

Figure 16.

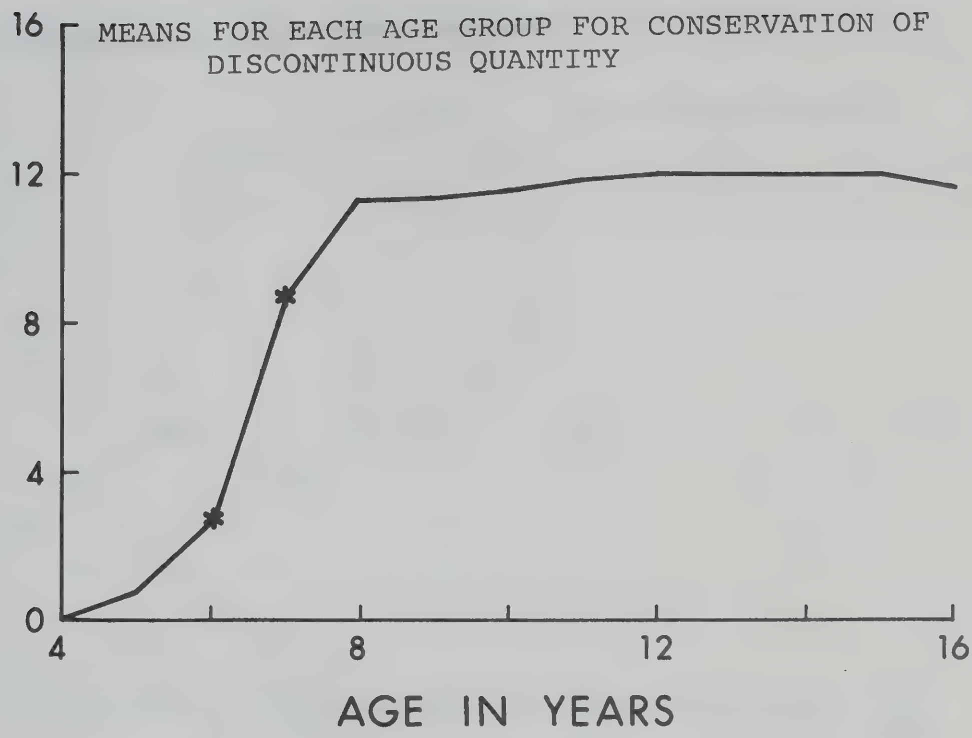
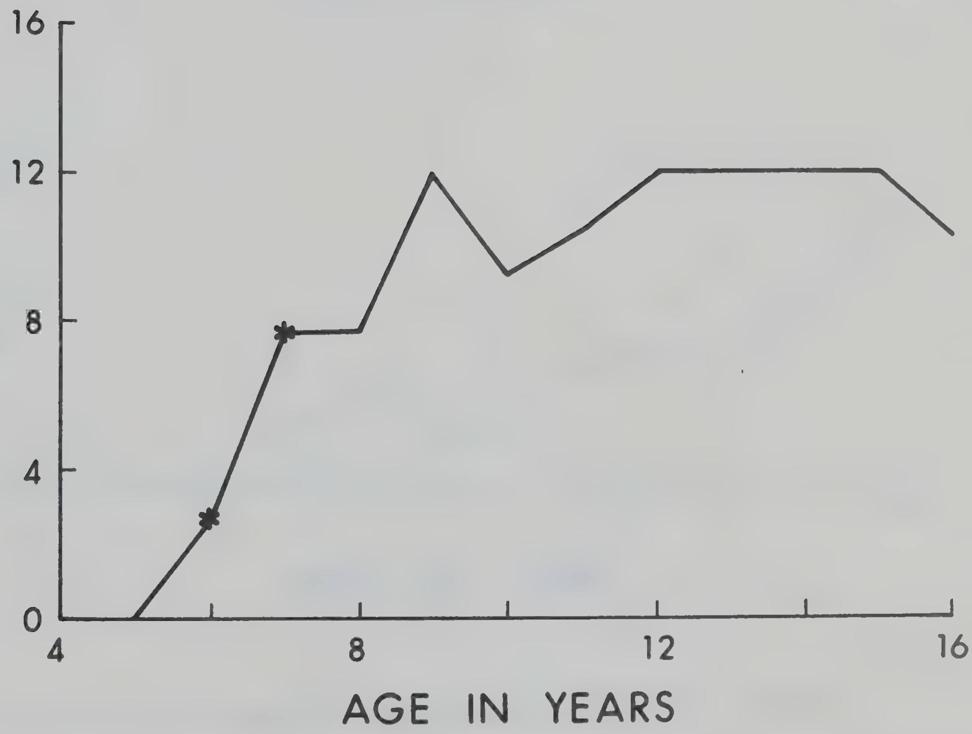


Figure 17.



MEANS FOR EACH AGE GROUP FOR CONSERVATION OF WEIGHT

Figure 18.

MEANS FOR EACH AGE GROUP FOR CONSERVATION OF AREA

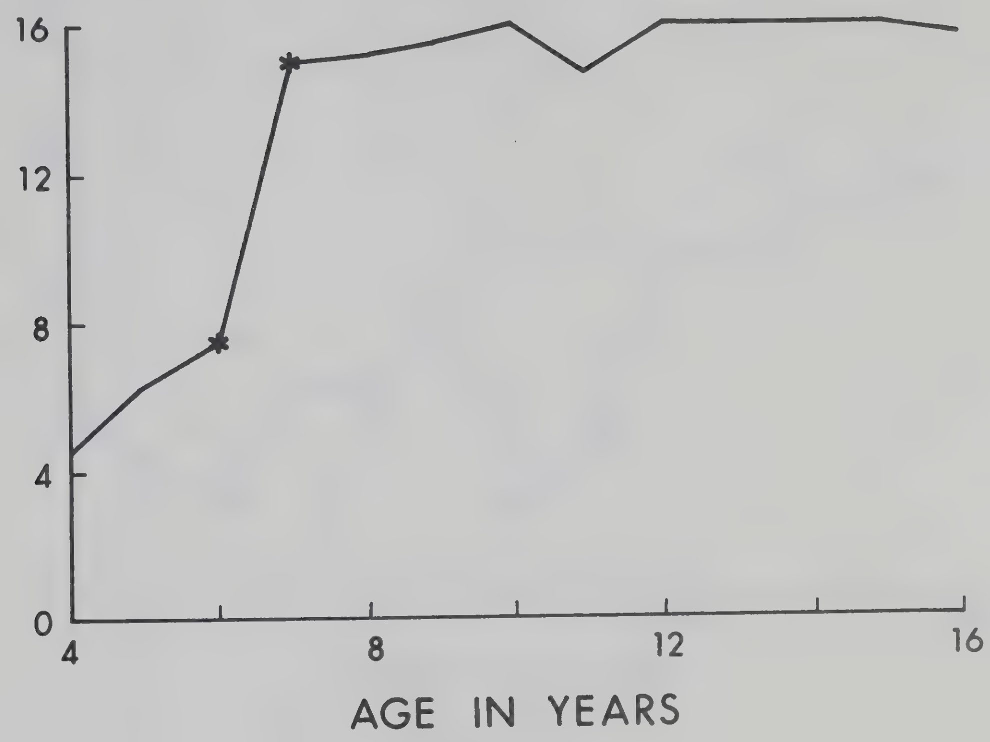
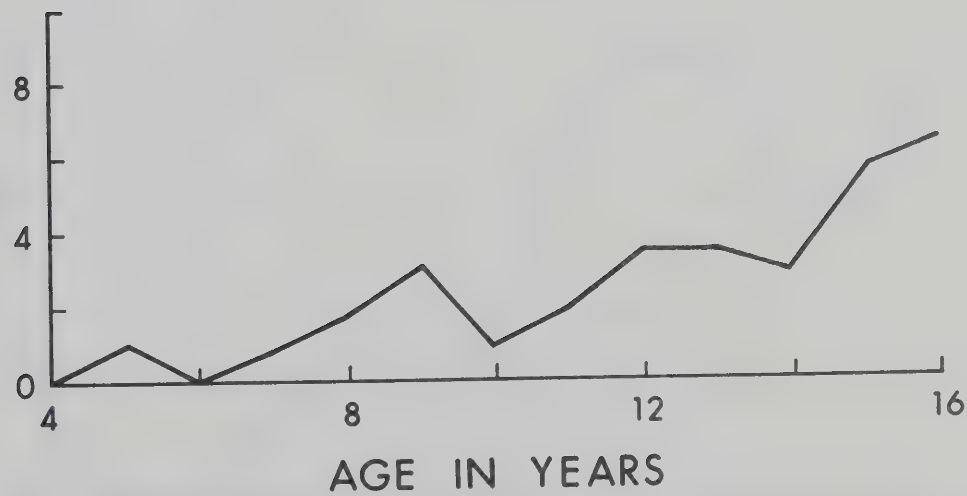


Figure 19.



MEANS FOR EACH AGE GROUP FOR CONSERVATION OF VOLUME

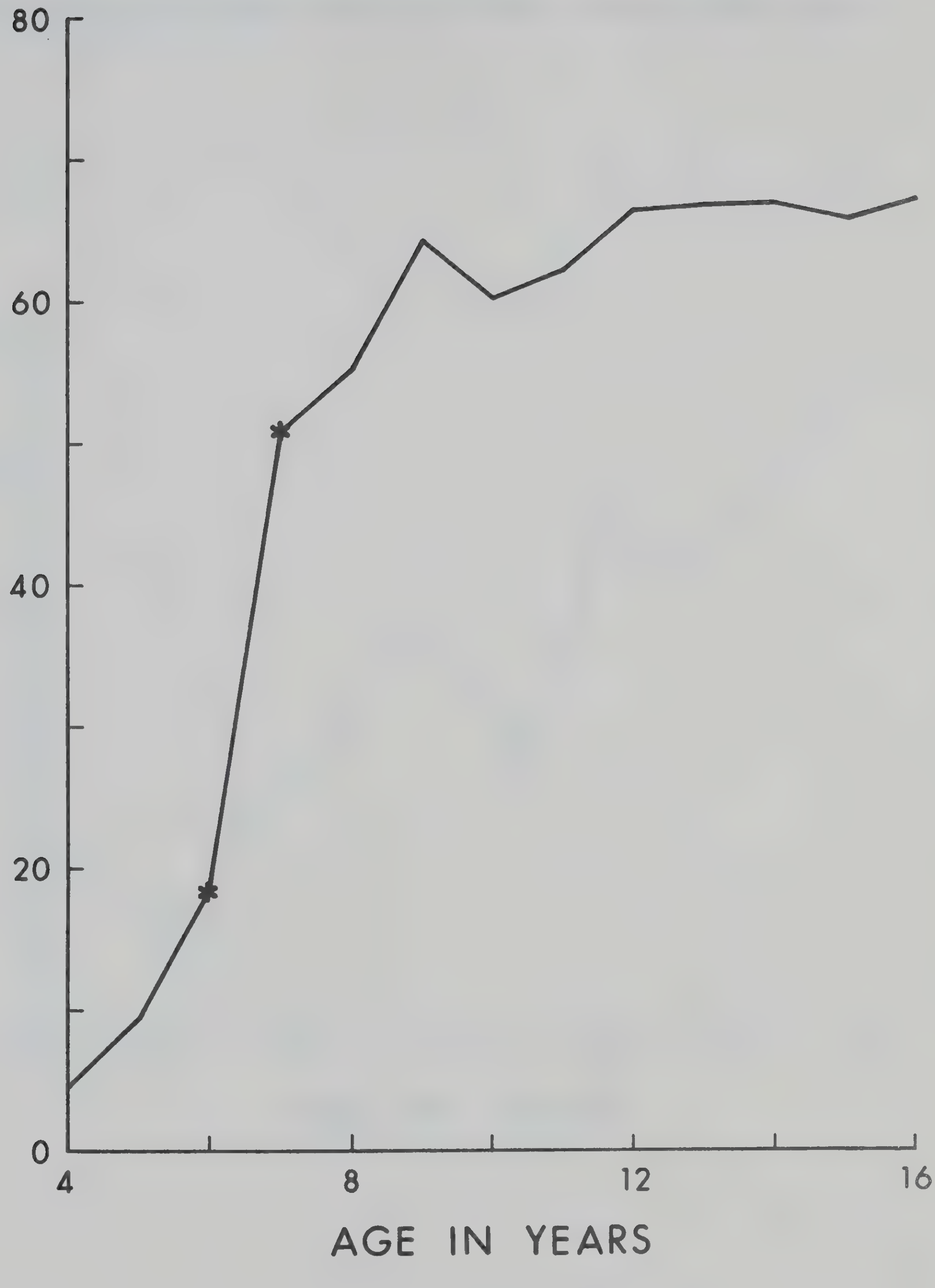
Figure 20.

MEANS FOR EACH AGE GROUP FOR CONSERVATION OF DENSITY

Figure 21.

MEANS FOR EACH AGE GROUP FOR THE FORMAL OPERATIONS QUESTION

Figure 22.



MEANS FOR EACH AGE GROUP FOR ALL CONCRETE CONSERVATION TASKS

Figure 23.

MEANS FOR EACH AGE GROUP FOR ALL FORMAL OPERATIONS TASKS

Figure 24.

MEANS FOR EACH AGE GROUP FOR THE TOTAL CONSERVATION SCORES ON ALL PIAGETIAN TASKS

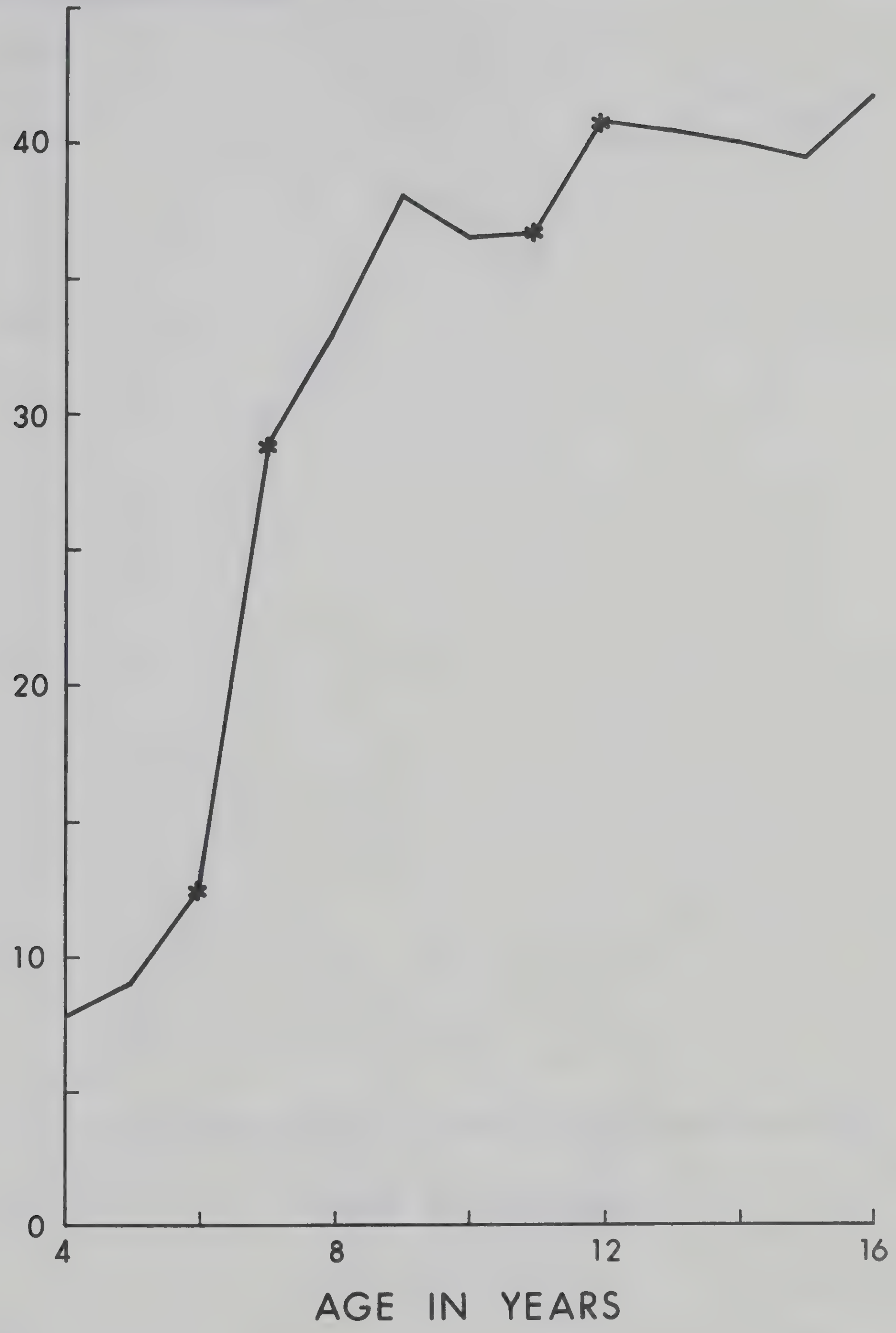


Figure 25.

MEANS FOR EACH AGE GROUP FOR THE TOTAL EXPLANATION SCORES ON ALL PIAGETIAN TASKS

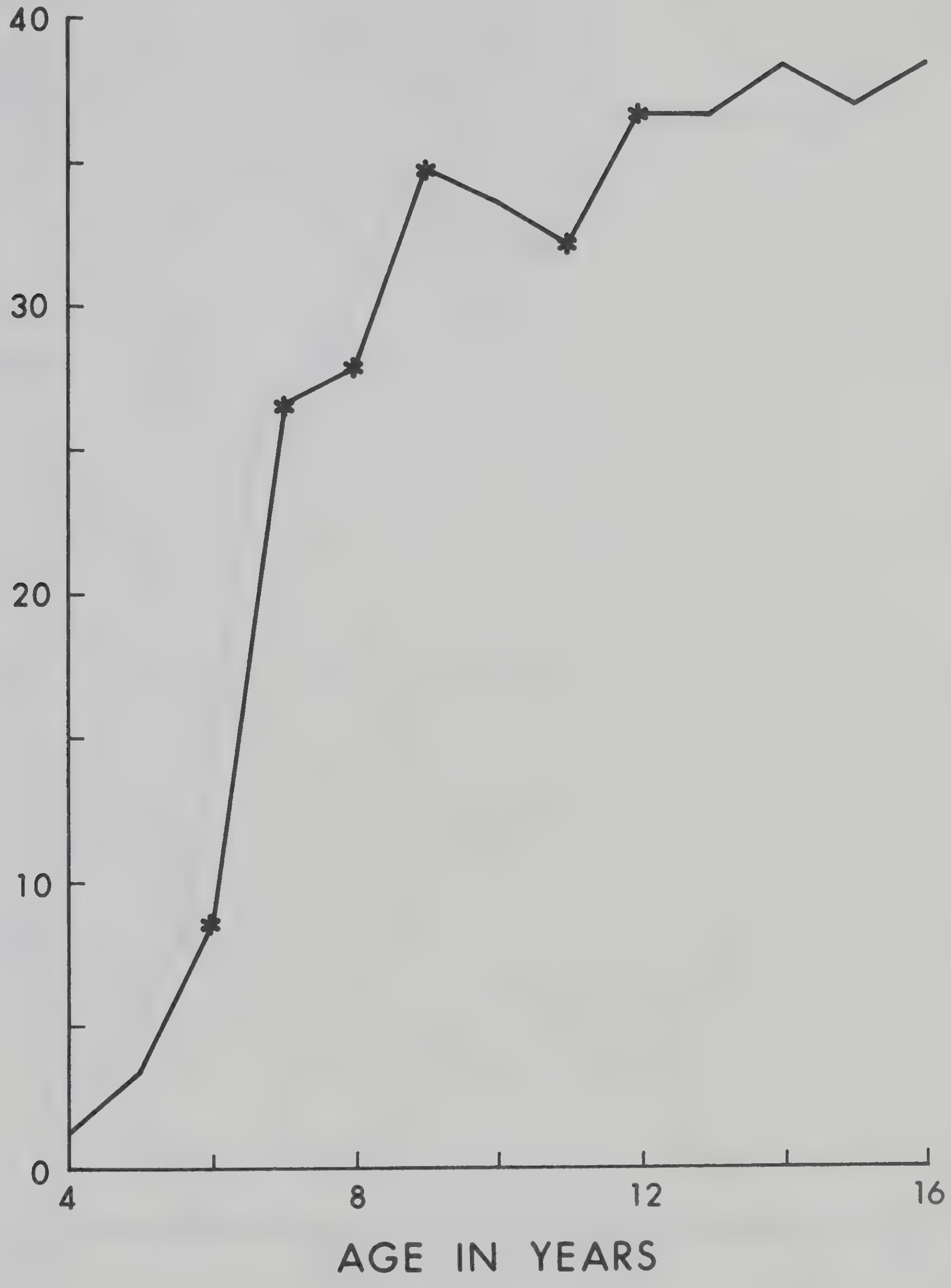
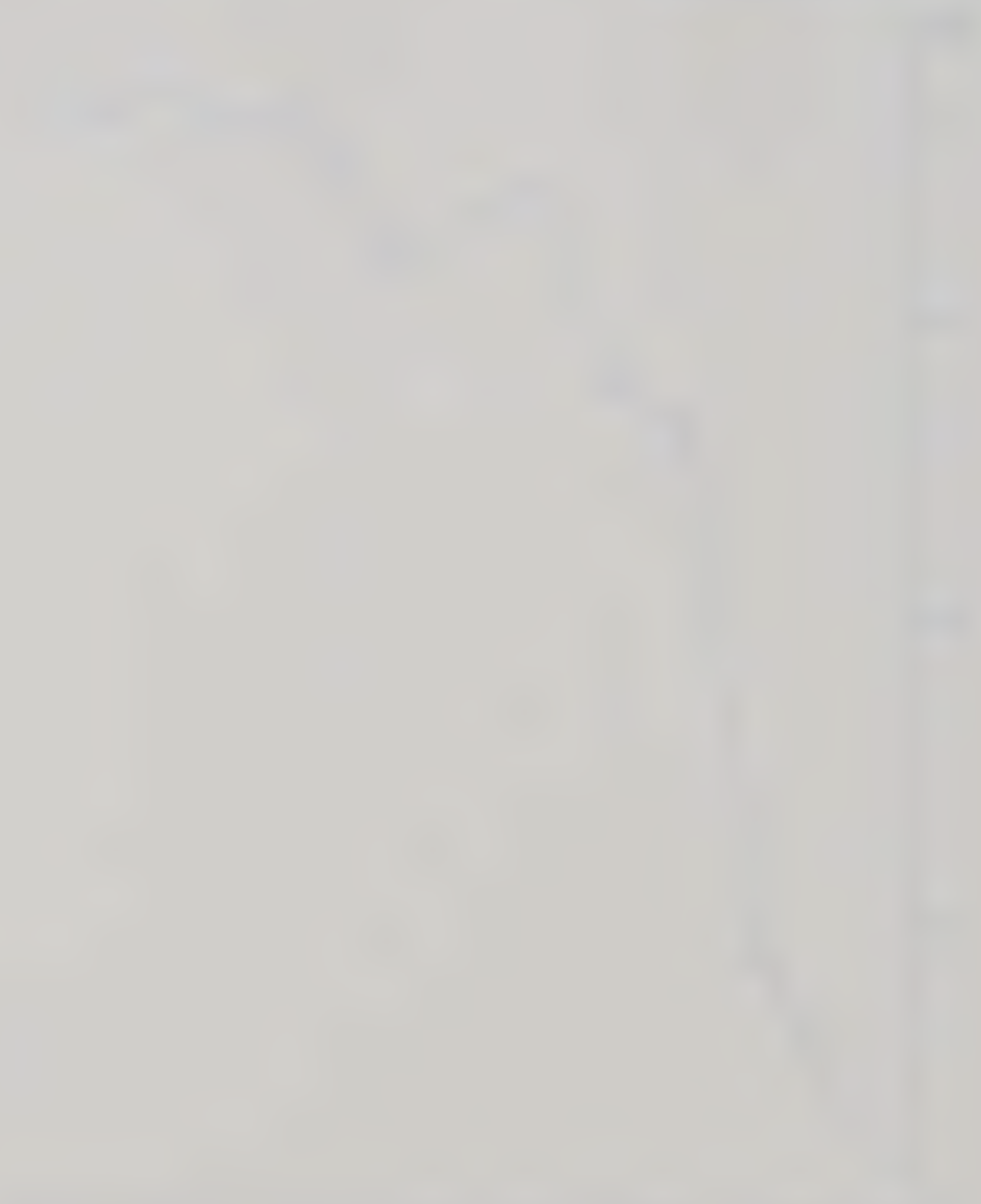
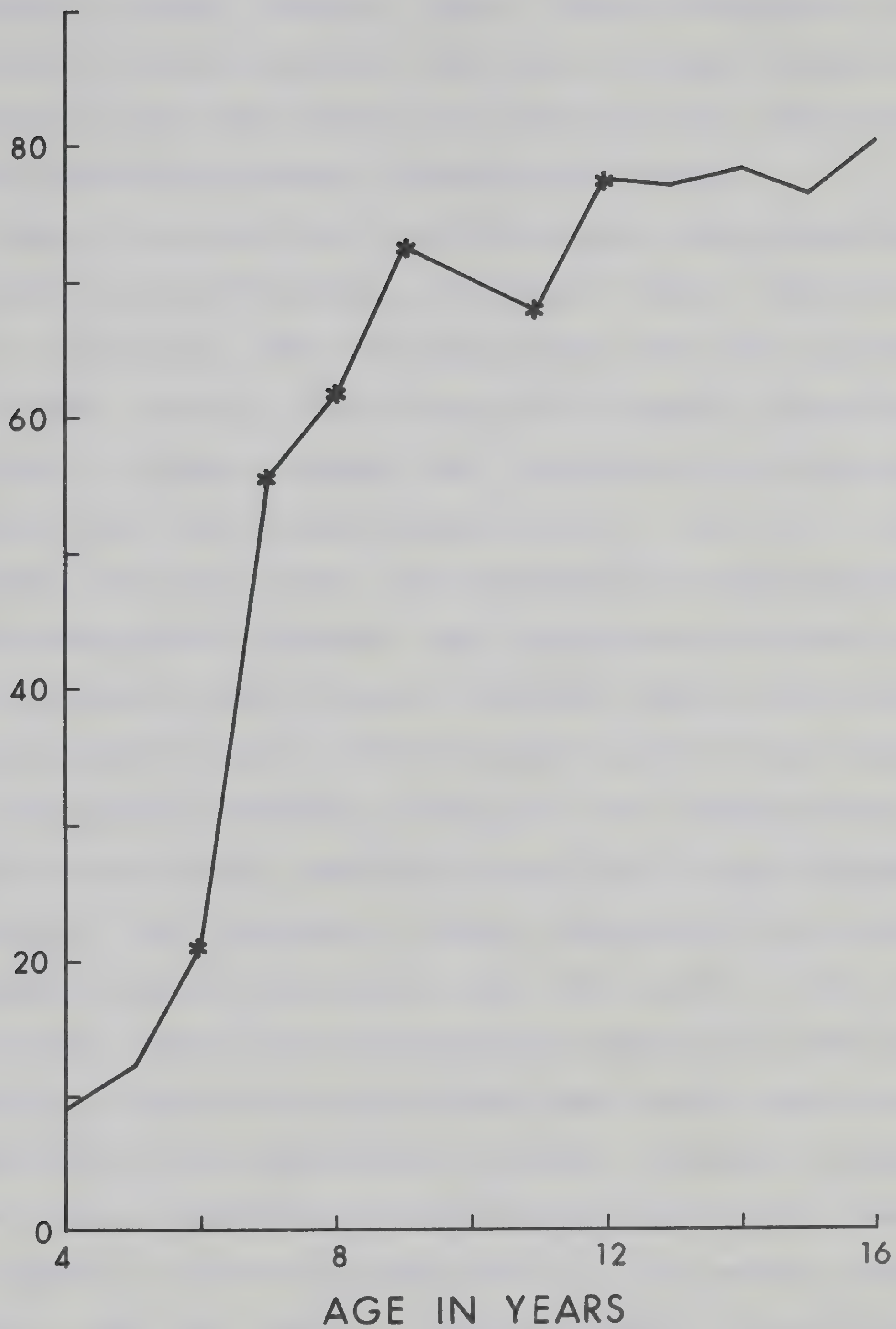


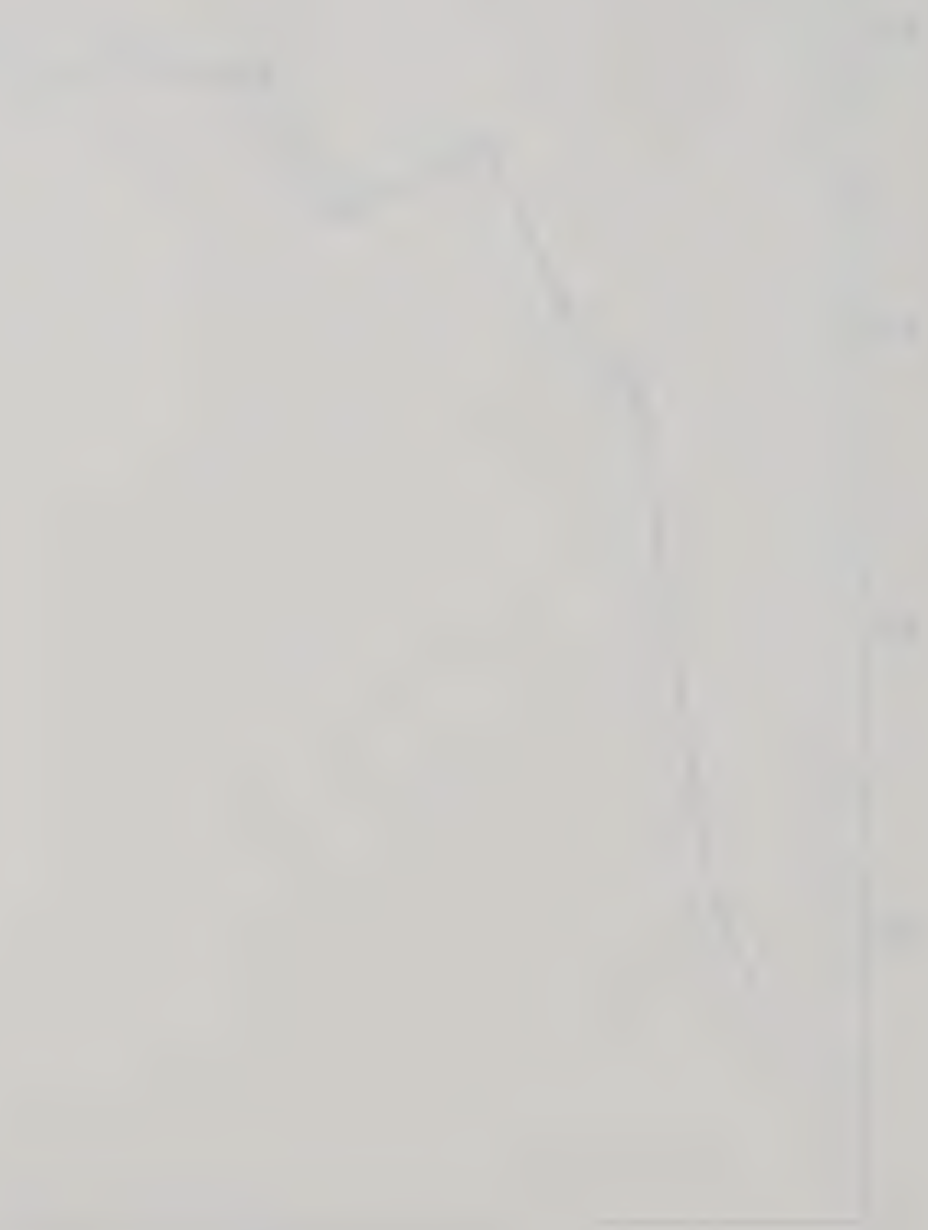
Figure 26.





MEANS FOR EACH AGE GROUP FOR THE GRAND TOTAL OF ALL PIAGETIAN SCORES NO TITLE

Figure 27.



"guessing" luck, rather than truly reflecting more sophisticated understanding. Neither the Volume problem nor the Formal Operations Question revealed any significant differences in performance throughout the sample.

When the scores for all the concrete operations level tasks are considered together, the 6 and 7 year distinction again illustrates the Pre-operational and the Concrete Operational Stages. Considering the formal operational tasks as a group reveals two significant differences; between 6 and 7 years, and between age 11 and 12. Thus although distinct stages did not emerge on the individual formal tasks, taken together they provide clear evidence of all of Piaget's major stages. The first three ages operate similarly, as do the 7 - 11 year olds, and the 12 and older. These divisions correspond exactly to the Pre-operational, Concrete Operational, and Formal Operational Stages proposed by Piaget. An identical pattern emerges for the initial judgement scores considered over all tasks. Both the explanation scores for all Piagetian problems and the Grand Total of all scores for all problems also reveal significant breaks at the ages hypothesized to border Piaget's stages, as well as an additional distinction between 8 and 9 years. This suggests that all children ages 7 - 11 perform about equally well in terms of making initial conservation judgements, but the 6, 10, and 11 year olds have a better understanding of the principle underlying conservation, and

so can explain the phenomenon better than the 7 and 8 year olds.

Thus, the t tests strongly support the division of conservation tasks into concrete and formal operational types. Each individual concrete conservation problem appears to reliably reflect whether a given subject is operating at the Pre-operational or the Concrete Operational Stage, but the individual formal level tasks do not discriminate between stages as well. Several formal operations tasks taken together however, do appear to reliably reflect all three of Piaget's major stages. The pattern obtained from the initial judgements scores also mirrors the three stages; but when the explanation criterion is considered as well, finer distinctions between the early and late Concrete Operational Stage become apparent.

More specific aspects of the subject's manner of responding to the conservation tasks are explored in Table 36. These categories were devised by Little (1972) to reflect the three-stage sequence, proposed by Piaget and Inhelder (1964), of transition between pre-operational and concrete level thought. Level 1 includes categories 1, 2, and 3, so involves lack of comprehension of the concepts of "same" "more" or "less" and/or very immature, silly or random behaviour. This type of response occurred vary rarely in the present study, as only 12 per cent of the four year olds operated primarily in this manner. Nine and ten

TABLE 36

TYPES OF RESPONSES TO CONSERVATION TASKS IN TERMS OF LITTLE'S CATEGORIES (1972)

Little's (1972) Categories Age	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1 Random Actions						2.2								.16
2 Global Response	7.1					.5	.5							.62
3 Negative or Silly						1.0								.08
4 Perceptual Response, No Explanation	27.2	20.7	.5	.5		1.0								3.84
5 Perceptual Response, Explanation	46.7	54.3	70.1	29.3	24.4	15.8	18.5	22.8	12.5	13.6	15.2	13.0	12.5	26.83
6 Concrete, Measuring	2.2	1.6	1.6	1.6		1.0								.62
7 Changed Answer, No Explanation	1.1	1.6	2.7	3.3	3.3	1.6	2.7		1.6	1.0		1.0		1.54
8 Changed Answer, Explanation		1.0	.5	.5	1.0	1.0			.5					.37
9 Knew Answer, No Explanation	13.6	14.1	8.2	9.8	9.8	8.7	8.7	7.1	9.2	8.6	3.3	4.3	5.4	8.52
10 Knew Answer, Correct Explanation	2.2	6.5	16.3	54.3	61.4	66.8	69.6	70.1	76.1	76.6	81.5	81.5	82.1	57.35
Total Levels (from Little, 1972; Piaget and Inhelder, 1964)														
Level 1 (Categories 1, 2, and 3)	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Level 2 (Categories 4 to 9)	87.5%	100.0%	87.5%	37.5%	12.5%	0.0%	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Level 3 (Category 10)	0.0%	0.0%	12.5%	62.5%	87.5%	100.0%	87.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

year olds supplied the occasional answer of this type, but no one subject at these ages gave more than one or two Level 1 replies.

Level 2 involves categories 4-9, which are suggestive of task comprehension but intuitive reasoning, as the subjects could make comparisons on the basis of one dimension only. The majority of the 4, 5 and 6 year olds were found to be operating in terms of this mode, as well as a few of the other ages up to about age 10. Thus, most pre-operational subjects in the present study fell at this level, which is somewhat in contrast to Little's findings for children in the average range of intelligence. Perhaps the fact that the present sample was selected on the basis of emotional as well as intellectual criteria accounts for this discrepancy. Both studies confirm, however, that Level 2 predominates until about 7 years of age, which is also in keeping with Piaget's position on the matter. Most children at this intuitive stage provided perceptually oriented responses and were able to explain this to the examiner, regardless of their age. A few of the 4 and 5 year olds used a similar basis but were unable to adequately explain the fact. Some responses at each age level clearly suggested the child knew the correct judgement instantly, but could not justify it. This occurred mostly at the younger age levels tested. Level 3 included category 10 only, and is therefore representative of concrete logic. As

expected, this stage emerged at age 7 and dominated the remaining years.

Consideration of the specific types of pre-operational responses, over all age levels, reveals the perceptual response was by far the most frequently used. Intuitive knowledge without explanation follows, but accounts for only 8.5 per cent of the total. Interestingly, only about 2 per cent of the total answers involved a change in initial conservation judgement. This supports Piaget's notion that conservation reflects true concepts in which the children believe implicitly. Of course, well over half of the subjects' responses are suggestive of full conservation and concrete operational stage thought. These answers are explored further below, in terms of the categories of other investigators.

Table 37 includes the type of conservation responses given by all ages to each individual task, in terms of Little's categories. The precentage of Level 3 answers directly reflects the difficulty of the problem in question; thus, all concrete level conservations involve mostly this type of response. The more challenging formal level tasks on the other hand, were answered and explained adequately only about 20 per cent of the time. The volume problem tended to be perceptually approached with some explanation attempted, as 68 per cent of the answers given were of this type. This area was also the most confusing, as more

TABLE 37

PERCENTAGE OF SUBJECTS GIVING VARIOUS TYPES OF RESPONSES FOR EACH TASK (CATEGORIES FROM LITTLE, 1972)

Variable	Substance	Continuous Quantity	Discontinuous Quantity	Weight	Area	Volume	Density
1 Random Actions, Lacks Concepts of "More" or "Same"	.32	.96					
2 Global Undifferentiated Responses	.96	.64	.64	1.28	.24	.96	
3 Negative or Silly, Tangential Answers						.32	.24
4 Perceptual Attribute; No Explanation	5.44	3.2	3.52	3.84	1.63	4.8	4.80
5 Perceptual Attribute; Explanation	18.26	17.94	15.7	26.6	10.33	67.94	34.13
6 Makes Comparisons Using Fingers, etc.		.32	1.6	1.28	.24		.96
7 Changed Answer; No Explanation	1.28		1.92	.32	.96	4.48	1.92
8 Changed Answer; Explanation		.32	.64	.64	.48	.32	.24
9 "Knew Answer"; No Reason Given	4.16	1.92	1.92	.96	3.36	.96	38.22
10 "Knew Answer:; Explanation	69.55	74.67	74.03	65.06	82.69	20.19	19.47

replies involved a change of judgement here than on any other task. As expected from other findings, many subjects intuitively knew the answer to the density problem, but could not explain the phenomenon involved. Those who did not respond in this manner tended to attempt explanation on perceptual factors.

Table 38 focuses on the types of correct conservation explanations presented, rather than on the nature of the pre-operational responses. These categories were taken from Papalia (1972). Of course ages 4, 5, and 6 offered very few acceptable justifications for conservation, but what few there were tended to be of the counting type. By 6 years a few children also referred to the previous equality of the stimuli, and this mode gained a slight majority over counting at age 7. Eight, nine and ten year olds justified conservation by the addition-subtraction concept (ie. "you didn't add any or take any away") and/or by counting. The suggestion of reversibility began to be employed with some frequency around 11 years and accounted for about 12 per cent of all responses until age 14. From 11 years on, counting, reference to previous equality and addition-subtraction remained favorites, although "statement of operation performed" was most popular at 13 years. Considering all age levels together, addition-subtraction and counting were the most frequently offered justifications for conservation (about 14% each) with reference to previous

TABLE 38

PERCENTAGE OF SUBJECTS AT EACH AGE LEVEL USING VARIOUS TYPES OF CONSERVATION JUSTIFICATIONS (CATEGORIES FROM PAPALIA, 1972)

Variable Age	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Inadequate Explanation	97.8	93.5	83.2	45.1	38.0	28.3	31.8	30.4	24.4	24.4	20.2	20.2	19.9	43.6
Reversibility		1.1		3.8	3.3	1.7	11.4	12.7	12.5	13.1	4.2	4.8	10.2	6.0
Statement of Operation Performed			2.2	3.8	2.7	2.3	5.7	9.4	9.1	19.3	8.9	13.1	11.4	6.6
Addition - Subtraction			0.5	9.8	23.4	38.6	21.0	18.8	13.1	14.2	14.3	17.3	19.3	14.4
Compensatory - Relations Proportionality			0.5	0.5	1.6	1.2	0.0	6.1	2.3	4.5	0.6	4.2	3.6	1.9
Sameness of Materials Used			2.2	1.1	0.5	4.0	5.1		1.1		0.6	0.0	1.2	1.2
Reference to Previous State of Equality Between Stimuli			4.9	19.6	13.0	7.6	6.8	5.0	19.3	6.2	32.1	21.4	15.1	11.4
Counting	2.2	5.4	6.5	16.3	17.4	16.3	18.2	17.7	18.2	18.2	19.0	19.0	19.3	14.8

equality following quite closely (11%). Interestingly, the criteria involved in both the Little and Papalia systems "fit-together" exactly, as 43 per cent of the subjects responses were found to be pre-operational using the latter criteria, and 57% were judged operational on the basis of the former. This suggests that both sets of categories could be used together to cover both major stages of Piaget's theory.

Table 39 displays the types of justification used for each specific conservation task. Although counting responses were used by each age level, they were only put forward for one type of task - the Area Question. It appears that this problem was either answered in this way, or not answered at all, which raises the possibility that this task is actually more in the realm of number than anything else. If this is so, perhaps the traditional designation of Conservation of Area for the "Cows and Barns task" is in error. Regarding this problem as Conservation of Number might be more correct, judging by these findings. All other concrete level conservation tasks were primarily justified in terms of addition-subtraction, with the previous equality idea following in popularity by an often considerable margin. "Statement of operation performed" was also used a fair amount in the quantity questions, and reversibility occurred to some extent in regard to substance. Of the few proper explanations given for volume,

TABLE 39

PERCENTAGE OF SUBJECTS USING VARIOUS TYPES OF CONSERVATION EXPLANATION FOR EACH TASK (CATEGORIES FROM PAPALIA, 1972)

Variable	Substance	Continuous Quantity	Discontinuous Quantity	Weight	Area	Volume	Density
Inadequate Explanation of Conservation	30.1	25.4	25.8	34.3	16.7	78.5	99.4
Reversibility	14.7	8.0	8.7	8.0		4.8	
Statement of Operation Performed	11.2	13.8	16.1	6.1		1.9	
Addition - Subtraction	23.7	30.2	27.1	23.7		1.9	
Compensatory - Relations - Proportionality	2.2	4.8	4.2	0.6		2.2	
Sameness of Materials Used	1.3	1.6	1.0	2.2	1.2	0.6	0.6
Reference to Previous State of Equality	16.7	15.8	17.1	25.0		9.9	
Counting					82.1		

most involved a reference tc previous equality, and all density explanaticns referred tc the sameness of materials used.

Papalia found that the type of justification used for each conservation task did not differ noticeably across the various age levels, which is in keeping with present results. The most popular explanations offered in her study were "statement of the operation performed" and "reference to previous equality". Here addition-subtraction and counting were most frequently used, but the present study used much younger subjects and a somewhat larger battery of tasks than her more adult oriented investigation.

Brainerd's explanation categories were devised more in terms of the formal operations tasks so were included as well. This system has the advantage of breaking up the reversibility mode into two types; inversion reversibility which is the fact that perceptual deformations could always be reversed, and reciprocity, which involves the concept that changes in certain dimensions are compensated by changes in other related dimensions. It also includes a category for conceptually irrelevant explanations which are not based on simple perceptual aspects of the stimuli, nor which have anything to do with why conservation obtains. This aspect seemed to be particularly relevant to the more difficult and abstract problems. Table 40 illustrates the performance of the various age groups in terms of Brainerd's

TABLE 40

PERCENTAGE OF SUBJECTS USING VARIOUS TYPES OF CONSERVATION JUSTIFICATIONS
(CATEGORIES FROM BRAINERD, 1971)

Variable	Age	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Inversion - Reversibility			1.1		3.8	3.3	1.1	10.9	12.5	12.0	12.5	3.8	4.3	9.2	5.7
Reciprocity - Reversibility		1.1	5.4	16.8	41.3	35.3	29.9	38.6	39.1	52.2	50.0	64.7	61.4	55.4	37.9
Addition - Subtraction		0.5		1.6	10.9	23.9	38.5	20.1	18.5	12.5	14.1	13.0	15.8	17.4	14.3
Conceptually Irrelevant		8.2	3.3	4.9	13.0	8.7	17.5	8.7	9.8	13.0	12.0	6.0	8.2	8.7	9.3
Perceptual		70.3	61.4	70.7	29.9	28.3	10.2	21.7	20.1	10.3	11.4	12.5	10.3	8.7	28.3
Don't Know		19.8	28.8	6.0	1.1	0.5	2.8							0.5	4.6

system of classifying conservation rationales.

The first three categories listed in the table are acceptable types of conservation justifications, the last three are examples of inadequate explanations. The perceptual mode dominated the first three ages, and the "don't know" types are found mostly among the 4 and 5 year olds. Reciprocity-reversibility was used to some extent at age 6 and gains majority at age 7; thus, as expected, true comprehension of the conservation phenomenon comes to the fore at this level. Addition-subtraction was the preferred mode of the 9 year olds, and continued to be of secondary importance at all upper age levels. Reciprocity-reversibility was the most popular rationale from age 10 on, reaching a majority of 65 per cent at 14 years. It was also the most frequently used when all age levels are considered together, followed by the inadequate "perceptual" mode and the acceptable "addition-subtraction." The fewest incorrect responses were of the "don't know" type, and the fewest correct explanations involved inversion reversibility.

In terms of individual tasks, Table 41 reveals that the reciprocity mode dominated all concrete conservations, including the area problem as "counting" does not appear in Brainerd's categories. Addition-subtraction was also popular for these less difficult tasks, as were the perceptual responses among those who could not adequately conserve. Inversion-reversibility was not used extensively,

TABLE 41

PERCENTAGE OF SUBJECTS USING VARIOUS TYPES OF CONSERVATION JUSTIFICATIONS FOR EACH TASK (CATEGORIES FROM BRAINERD, 1971)

	Substance	Continuous Quantity	Discontinuous Quantity	Weight	Area	Volume	Density
Inversion - Reversibility	14.5	8.1	9.0	8.0		4.5	
Reciprocity - Reversibility	31.8	36.5	38.4	33.3	82.6	14.5	19.8
Addition - Subtraction	24.1	30.6	27.1	24.4	0.2	2.3	0.5
Conceptually Irrelevant	3.9	1.3	2.3	3.2	1.7	0.6	43.1
Perceptual	20.9	20.6	20.6	26.0	11.4	74.9	28.2
"Don't Know"	4.8	2.9	2.6	4.8	4.1	3.2	8.4

but it did account for 14 per cent of the substance responses. At the formal level, perceptual rationales dominated the Volume task, and conceptually irrelevant replies were most often offered for Density. Those who did perform acceptably in these areas nearly always used the reciprocity justification. Conceptually irrelevant justifications were almost never given for Volume, as Brainerd also found. Inversion did not apply at all to Density, owing to the nature of the problem. It could possibly have been applied to Area, but nobody used it that way, preferring the more concrete counting mode.

Thus it seems Brainerd's system is of great advantage for the Density problem, but does not emerge as much superior as regards Volume. It does not include the fine categories of the other systems mentioned, but seems a reasonable summary of the major types of conservation response.

Comparison of the Piagetian and the Vygotsky Results

The correlations among the individual Piagetian tasks and the Vygotsky variables are contained in Table 42. All are significant at either the .05 or the .01 level except "Number of Hypotheses" which does not relate significantly to any of the Piagetian results, "Time to First Grouping" which differs significantly from the Volume and Density results, "Total Time" which is independent of Volume, and "Number of Different Hypotheses" which does not relate to

TABLE 42

CORRELATIONS AMONG THE PIAGET TASKS AND THE VYGOTSKY VARIABLES

Vygotsky Variables	Substance	Continuous Quantity	Discontinuous Quantity	Weight	Area	Volume	Density	Formal Operations Question
Time to First Grouping	-.236	-.272	-.273	-.257	-.347	-.129*	-.066*	-.204
Basis of First Grouping	.457	.495	.488	.337	.351	.183	.198	.206
Number of Examiner Clues	.500	.525	.534	.427	.452	.291	-.410	-.394
Total Time	.291	.324	.324	.294	.344	.164*	-.307	-.262
Number of Hypotheses	.122*	-.140*	.119*	.188*	.165*	-.007*	-.076*	-.030*
Number of Different Hypotheses	.480	.492	.483	.54	.391	.222	.179*	.259
Level of Verbalization (re: size)	-.791	-.820	-.805	-.654	-.728	-.240	-.333	-.346
Level of Verbalization (re: double dichotomy)	-.714	-.718	-.708	-.545	-.633	-.277	-.409	-.502
Time for Final Regrouping	-.440	-.484	-.468	-.386	-.523	-.202	-.272	-.260
Number of Errors in Regrouping	-.669	-.674	-.658	-.551	-.514	-.238	-.258	-.276
Rater #1	.562	.601	.592	.488	.546	.308	.419	.465
Rater #2	.562	.601	.592	.488	.546	.312	.419	.458
Rater #3	.584	.612	.610	.498	.556	.334	.434	.455
Overall Vygotsky Rating	.522	.527	.536	.446	.489	.369	.416	.426

*Not significant at either the .05 or the .01 level.

the Density task. It will be recalled that the "Number of Hypotheses" dimension also did not correlate significantly with either age or the other Vygotsky variables, and was one of the poorest predictors of age. This extreme independence raises the possibility that perhaps this variable is in no way reflective of cognitive sophistication. The remaining non-significant correlations occurred on the most difficult Piagetian tasks, which also were the poorest reflectors of Piaget's theoretical stage model. On the whole the highest correlations between measures from each system occurred on those variables that correlated well with both other scores from the same system and with age. These variables also predicted age well, and were most representative of the overall theoretical model involved. This pattern supports both the validity of the theoretical models of cognitive development, and the closeness of their relationship. Although the "Level of Verbalization" measures provide the very highest correlations with the concrete level conservation tasks, the rater's data and the overall estimation of Vygotsky stage consistently related the closest to all of the individual Piagetian tasks, no matter how difficult. This is as would be expected, as the individual Vygotsky scoring variables were not found to reflect the overall Vygotsky stage model as well as the rater's judgements.

Table 43 illustrates the correlations among the total

TABLE 43

CORRELATIONS AMONG THE PIAGET TASKS AND THE VYGOTSKY VARIABLES

Vygotsky Variable	Total C Scores for Concrete Tasks	Total E Scores for Concrete Tasks	Total Scores for Concrete Tasks	Total C Scores for Formal Tasks	Total E Scores for Formal Tasks	Total Scores for Formal Tasks	Total of Concentration Scores	Total of Explanation Scores	Grand Total
Time to First Grouping	-.311	-.307	-.310	-.116*	-.143*	-.134*	-.286	-.302	-.299
Basis of First Grouping	.478	.434	.460	.194	.301	.255	.467	.447	.455
Number of Examiner Clues	-.534	-.557	-.549	-.407	-.507	-.472	-.548	-.594	-.580
Total Time	-.330	-.357	-.346	-.295	-.325	-.321	-.352	-.386	-.375
Number of Hypotheses	.152*	.135*	.145*	.059*	.053*	.058*	.127*	.105*	.115*
Number of Different Hypotheses	.527	.526	.529	.217	.299	.266	.501	.518	.514
Level of Verbalization (re: size)	-.804	-.806	-.810	-.329	-.419	-.386	-.775	-.799	-.796
Level of Verbalization (re: double dichotomy)	-.710	-.724	-.722	-.419	-.503	-.477	-.721	-.739	-.735
Time for Final Regrouping	-.515	-.503	-.512	-.276	-.339	-.318	-.515	-.509	-.518
Number of Errors in Regrouping	-.644	-.674	-.664	-.251	-.386	-.328	-.610	-.670	-.647
Rater #1	.624	.631	.633	.449	.506	.494	.640	.656	.656
Rater #2	.624	.629	.632	.454	.504	.504	.496	.640	.655
Rater #3	.639	.650	.651	.472	.527	.518	.656	.676	.675
Overall Vygotsky Rating	.551	.588	.575	.477	.525	.519	.584	.614	.603

Piagetian scores and the Vygotsky variables. Here again, "Number of Hypotheses" emerges as the only measure that differs significantly from every Piagetian score; however, "Time to First Grouping" does not relate to any of the formal level totals. Overall, a virtually identical pattern to that reported in Table 42 emerges, although the individual correlations are slightly higher, as on the whole the total Piagetian scores fit the theoretical model better than the individual tasks. Again the highest correlations occur between "Level of Verbalization" and the concrete tasks, but the measures based on Vygotsky's actual stages emerge as most consistently superior.

The correlations between the numerical equivalents of the stages in each theoretical system are found on Table 44. Piagetian stages were considered on the basis of both the initial judgements and the explanation criteria, but the Vygotsky estimations included substages as well. Although all are significant (except, of course, "Number of Hypotheses"), it is probable that the relationships would have been somewhat higher if only the three major Vygotsky stages had been included. Nevertheless, "Level of Verbalization" shows the closest relationship to the Piagetian stages whether explanations are considered or not. The rater's estimations are ranked closely behind. Of course, the most vital correlations as regards similarity of the stage concepts of both theories are those involving the

TABLE 44

CORRELATIONS AMONG THE PIAGET STAGE RATINGS AND THE VYGOTSKY VARIABLES

Vygotsky Variable	Overall Piagetian Stage - Without Explanation	Overall Piagetian Stage - Explanation Considered
Time to First Grouping	-.237	-.254
Basis of First Grouping	.382	.355
Number of Examiner Clues	-.591	-.557
Total Time	-.388	-.337
Number of Hypotheses	.007*	-.017*
Number of Different Hypotheses	.422	.348
Level of Verbalization (re: size)	-.637	-.644
Level of Verbalization (re: double dichotomy)	-.668	-.643
Time for Final Regrouping	-.428	-.418
Number of Errors in Regrouping	-.550	-.515
Rater #1	.613	.619
Rater #2	.609	.623
Rater #3	.626	.626
Overall Vygotsky Stage	.586	.550

*Not significant at either the .05 or the .01 level.

rater's and the Piagetian stages, as well as the one between the overall estimation of Vygotsky stage and the Piagetian stages.

In order to properly interpret the significance of these obtained correlations, it is necessary to first consider Table 45, which contains the percentages of the total sample falling in each major stage, on the basis of each system. It is abundantly clear that very few of the sample were placed in Vygotsky's first phase (4.8%) in comparison to Piaget's first stage (25.96% in the initial judgement criteria, 27.88% when explanation is considered). Thus, the obtained levels of correlation seem quite respectable, in view of the fact that one category contains a discrepancy of this magnitude. The other stages appear quite comparable among the systems, although the explanation criterion for the Piagetian data is somewhat more stringent than the others, as it places the smallest number at the highest stage.

Thus, the correlational data confirms H_1, but the unexpected finding that so few children aged four and above operate in terms of the Phase of Syncretic Images suggests that this phase is not actually comparable to Piaget's Pre-operational Stage. The fact that Vygotsky considers this level one of only three major phases certainly suggests it must have appeared with considerable frequency at some ages. Thus, one can only conclude that it must have occurred

TABLE 45

PERCENTAGE OF THE TOTAL SAMPLE FALLING AT EACH MAJOR THEORETICAL STAGE

On the Vygotsky Blocks	
Phase of Syncretic Images	4.8%
Phase of Complexes	58.65%
Phase of Conceptual Thinking	36.53%
On the Piagetian Tasks - Considering Judgement Only	
Pre-operational Stage	25.96%
Concrete Operational Stage	43.26%
Formal Operational Stage	30.76%
On the Piagetian Tasks - Considering Explanation	
Pre-operational Stage	27.88%
Concrete Operational Stage	50.96%
Formal Operational Stage	21.15%

primarily at younger age levels than were explored here. If this is in fact the case, then it is probable that the Phase of Syncretic Images actually compares more closely to Piaget's Sensory Motor Period, which is the chronological precedent of the Pre-operational Stage. If this is so, then it may further be assumed that Vygotsky's Phase of Complexes equates to Piaget's entire Period of Concrete Operations, including both the Pre-operational Stage and the Concrete Operational Stage.

On the basis of this new paradigm, 82 children (79% of the sample) were found to be operating within the Period of Concrete Operations and 22 (or 21%) at the Formal Operations level, when explanations were included in the criteria. Of those at the Concrete Period, approximately 7% were judged to be at the Phase 1 (Syncretic Images) level in the Vygotsky system, 68% at Phase 2 (Complexes), and 25% at Phase 3 (Conceptual Thinking). Seventy-eight per cent of the Formal Operations children were also functioning in terms of Vygotsky's Phase 3, and 22% fell within Phase 2. When explanations are not required for the Piagetian tasks, 72 children (or 69% of the sample) scored within the Period of Concrete Operations and 32 (31%) at the Formal Level. Of the Concrete group, 8% also scored at Vygotsky's Phase 1, 70% at Phase 2 and 22% at Phase 3. Of the Formal group, 69% fell at the expected Phase 3, and 31% at Phase 2. Thus the accuracy of prediction from one system to the other ranges

from 68%-77%, which seems a reasonable level of correspondence. The explanation criteria for Piaget more closely approximates the Vygotsky pattern, particularly at the highest conceptual levels, as the judgement only basis tends to place more Phase 2 subjects at the Formal Operational level. This finding supports Piaget's position that explanation is a necessity for accurate judgement of true conceptual level.

Chapter VI

Summary and Conclusions

Conclusions Drawn from the Vygotsky Investigation

The present research provides strong evidence that the Vygotsky Blocks are an appropriate instrument for the assessment of concept formation in children, and that Vygotsky's model of cognitive development is truly representative of children's thought processes *en route* to maturity. Clear evidence of all but one of Vygotsky's proposed phases and sub-phases occurred here, and all appeared in the expected order of sophistication. Vygotsky's division of the route to mature conceptualization into two separate branches was borne out by present findings, as children showed definite signs of starting to utilize rudimentary concepts even while the majority of their thinking involved complexes of varying levels of sophistication.

The relative rarity of behaviour indicative of the Phase of Syncretic Images in the present sample led to the conclusion that perhaps this phase predominates prior to four years of age. The suggestion was also put forward that dividing this first phase into sub-phases was unnecessary, as all but one of the children rated at this level operated

in terms of the Composite Subphase. If however, Phase 1 does occur primarily at younger ages than were included in this study, possibly most of the subjects were rated at this composite level because it is the most advanced aspect of the Phase, and the children tested were at the upper age limits involved. Either of these hypotheses may be correct, but only further research can accurately resolve the question in terms of one or the other. On the basis of present results alone, the division of the Phase of Syncretic Images into three subphases does not appear justified, but it is entirely possible that the lowest limit of Vygotsky's model was not tested. Vygotsky himself gives no clue as to the age of his youngest subjects. He does, however, suggest the the Phase of Conceptual Thinking is reached about puberty, and that consistent use of the very highest level of genuine concepts is not attained until adolescence. Present estimation of 12-13 years for the former and 15 for the latter confirms this expectation. Not all adolescents in the average range of intelligence were found to attain the capacity for forming genuine concepts, although the vast majority operated largely within the highest major phase.

The high level of inter-rater reliability obtained here indicates that it is possible for an observer to accurately place children's performance in terms of Vygotsky's stage criteria, even without the benefit of

witnessing the child's behaviour first hand. Present findings also indicate that the most accurate method of assessing performance was that used by the raters, which involved considering the child's overall performance in terms of Vygotsky's descriptions. However, it also proved possible to attain a reasonably accurate estimation of cognitive level by rating each individual grouping of the blocks and assigning an overall phase level on the basis of the types used most often.

The individual scoring variables devised by Meece and Rosenblum for the Vygotsky Blocks proved valuable indicators of various aspects of performance on the task, but did not reflect Vygotsky's actual cognitive stages too closely, although a definite relationship emerged. All of the dimensions correlated well with age and the other aspects of performance considered in both the Piagetian and Vygotsky investigations, with the exception of the number of hypotheses proposed by the child for groupings he made. Since this measure was also a relatively poor predictor of age level, it seems doubtful that it is in any way related to cognitive processes. Thus, it hardly seems worth retaining in the battery. Although no one individual dimension emerged as a valid single indicator of overall cognitive level, by far the best in all respects was the "Level of Verbalization", or the subject's ability to explain the principle underlying the Blocks. This variable

was divided into "sizes" and "double dichotomy" aspects in the present study, but this distinction emerged as largely unnecessary. "Level of Vervalization" consistently related most closely to the other variables explored in both Vygotskian and Piagetian systems, and was the best predictor of age. This suggests that verbal skills are of the utmost importance to conceptual development. The best non-verbal criteria of performance was the number of clues necessary for the subject to reach the final solution to the task, which functioned almost as well as "Level of Verbalization" for most purposes.

Unfortunately, at the present time there is no formula available to combine the Meece and Rosenblum variables into one total score, as several of the measures are in different mathematical units. Perhaps if this were possible, the results of the entire battery taken together would provide a better estimate of overall level of cognitive functioning. The measures were originally formulated in the hopes of providing a set of norms for children's performance on the Vygotsky Blocks. The correspondence between present results and those of the original investigators suggest that they would serve admirably in this capacity if more data were collected for the purpose. Present means and standard deviations found for each age level on the measures may be considered as modest preliminary norms.

Conclusions Drawn From the Piagetian Investigation

Piaget's model of cognitive development was also strongly supported by the present findings. In keeping with his proposed theoretical postulates, the Pre-operational Subperiod was found to encompass ages 4, 5, and 6, the Concrete Operational Subperiod emerged at 7 years and held majority until the Formal Operations Period, which was reached at 13 to 15 years of age. Major cornerstones of Piaget's theory such as notions of invariant sequence of attainment of cognitive skills and horizontal decalage were solidly borne out by this data. All types of statistical analysis led to the conclusion that conservation tasks may be legitimately divided into two types, those falling at the concrete operational level and those indicative of formal thought processes. Conservation of Substance, Continuous Quantity, Discontinuous Quantity, Weight, and Area emerged as the former type, while Conservation of Volume and Density represented the latter.

Although Piaget's overall theoretical model could be considered indisputably valid on the basis of present results, some variation occurred as regards the obtained difficulty levels and ages of attainment of the individual conservations explored. Conservation of Area consistently emerged as the most easily solved problem, followed by Continuous and Discontinuous Quantity (which were of roughly equal difficulty), Substance and Weight. The majority of

the seven year olds succeeded on all of these concrete level tasks, with most of the 6 year olds attaining conservation of area as well. Thus, Conservation of Weight occurred here a full two years before the age suggested by Piaget, and the Area problem proved immeasureably easier than anticipated. Variations in ages of attainment are not of crucial importance to Piaget's theory, as he considers any ages proposed as rough approximations only and states that considerable variation may be expected. He would probably view discrepancies of a year or two as quite trifling, especially when they occur within the limits of a major stage.

Variations in the order of difficulty of conservation tasks are a slightly more serious matter, although Piaget's horizontal decalage principle neatly accounts for discrepancies of this type. Both Piaget, and Goldschmid (1967) report Conservation of Area problems to be much more difficult than present results would indicate, although they both used a similar experimental method. There is little published research on the "Cows and Barns" area problems, but not one other investigator to date reports results similar to those of this study. The only plausible explanation for this phenomenon seemed to be that the present sample actually approached the problem differently, as most of the children responded more in terms of number than of overall area. Thus, the hypotheses was put forward

that perhaps today's children are more number oriented due to the influence of pre-school instructional television.

The formal operations level tasks all proved much more difficult than the early conservations, as the Formal Question was usually answered correctly at 11 years, with volume and Density emerging at about age 15. Volume was consistently rated the most difficult task in the battery, but Density showed the greatest variation in level depending on whether or not ability to explain the phenomenon was considered. On the basis of judgement alone Density was attained at 10 years. Whereas the younger age levels often responded "don't know" to other formal tasks, almost all were willing to hazard a guess to the Density problem. Perhaps this occurred because even very little children have experience in floating objects in water, so feel familiar with the situation involved. Brainerd (1971) interprets Piaget's position on age of acquisition of formal operations as between 11 and 15 years, although a good many of Piaget's own writings suggest these specific problems are usually solved closer to the lower age limit. Thus obtained results are well within reasonable limits, but specific ages of attainment on the individual tasks were slightly later than Piaget has suggested. Present results are in keeping with those of other researchers in formal tasks, however, all of the formal level tasks were among the best predictors of age level, but on an individual basis they did not predict

overall cognitive stage level as well as their concrete counterparts. Taken as a battery however, the formal tasks estimate stage very well.

Rather surprisingly, the best predictor of age was one of the simplest tasks, Conservation of Discontinuous Quantity. Its virtual twin in every other respect, Conservation of Continuous Quantity, emerged as the least effective predictor. This puzzling discrepancy may well have been a factor of order of administration of the tasks. Discontinuous Quantity always immediately followed the Continuous problem, so perhaps a learning factor was involved. It must have been of very slight magnitude, as the difficulty level of the two problems was virtually identical, but perhaps just a few children figured out the second problem due to exposure to the first. The ability to pick up on this factor was undoubtedly related to age, so this aspect may have served a particularly fine discriminator of older and younger subjects.

Piaget has steadfastly argued that the use of explanation criteria is a necessary part of conservation assessment; in fact he has probably been more adamant on that point than any other. Present analysis consistently confirms the superiority of the explanation criterion, but the difference between the two systems emerges as surprisingly slight in view of the storm of controversy this point has created in the literature. Only in the case of

the Density task is the difference substantial, as a five year gap in age of attainment occurs depending on the criteria accepted. The actual task administration used is probably very significant in this regard, as in the present study the children were thoroughly quizzed as to their judgements of same or different, more or less, and such. If there was even the slightest doubt of their confidence in judgement they were classified as non-conservers. This procedure was based on the hypothesis that if a child holds a real understanding of the matter in question he knows he knows and it is virtually impossible to sway him. Other investigators using judgement criteria often employed much less stringent estimations of conservation, such as completely non-verbal gestures or single judgements.

Conclusions Drawn from the Comparison of the Theoretical Models of Both Theorists

When the present study was originally devised, it was hypothesized that the two theoretical models of cognitive development would compare on the basis discussed in Chapter II. Although this involved the correspondence of a major Vygotsky phase with a mere sub-period in Piaget's system, it seemed a reasonable comparison in view of the fact that Vygotsky was not assumed to have investigated very young children. This conclusion was based on the knowledge that Vygotsky originally worked extensively with adults, and

later became interested in children when he was employed in an educationally oriented institution. This seemed to preclude youngsters below age four, so it was decided to begin the present investigation at this age.

Obtained results suggested that this assumption was erroneous, as only a very small percentage (4%) of the sample operated in terms of this first Phase, although a goodly number (25%) scored at the Pre-operational level on the Piagetian tasks. Thus it was concluded that Vygotsky's Phase of Syncretic Images probably equates more closely to the chronological precedent of the pre-operational stage in Piaget's model, the Sensory Motor Period. The diagram on the next page illustrates this revised comparative paradigm. This revised model is actually more theoretically sound than the orginal, as it equates the major developmental periods in both systems.

Correlations between the Vygotsky and the Piagetian variables revealed a significant degree of relationship for all aspects save the one Vygotsky score which also showed little correspondence to even its own scoring system. Thus, it may be concluded that the two models may be legitimately compared on both statistical and theoretical grounds.

Summary of the Hypotheses Explored in the Present Study

Table 46 depicts the hypotheses confirmed by this investigation. The major concern of course was H_1, which

REVISED COMPARATIVE DIAGRAM OF THE THEORIES OF COGNITIVE DEVELOPMENT OF J. PIAGET AND L. S. VYGOTSKY

VYGOTSKY'S MODEL	PIAGET'S MODEL
Phase of Syncretic Images Trial and Error Stage Perceptual Stage Composite Stage	Period of Sensory Motor Intelligence (birth to 2 years)
	Period of Concrete Operations (age 2 to 11) Subperiod of Pre-Operational Representations (age 2 to 7) Stage of Representational Operations (age 2 to 4) Stage of Simple Representations (age 4 to 5 1/2) Intuitive Stage (age 5 1/2 to 7)
Phase of Complexes Associate Stage Collections Stage Chaining Stage Diffuse Stage Pseudo-conceptual Stage	Subperiod of Concrete Operations (age 7 to 11)
Phase of Concepts Stage of Maximal Similarities Stage of Potential Concepts Stage of Genuine Concepts	Period of Formal Operations (age 11 years on)

TABLE 46

SUMMARY OF HYPOTHESES ACCEPTED AND REJECTED

H_1	-	Accepted
H_2	-	Accepted
H_3	-	Accepted for the ages indicated on the figures of each specific variable. Otherwise rejected.
H_4	-	Accepted
H_5	-	Rejected
H_6	-	A - Accepted
		B - Accepted
		C - Accepted
		D - Accepted
		E -- Accepted
		F - Accepted
		G - Rejected
		H - Rejected

was clearly supported by the correlational results. When the categorization of individual subjects was explored in terms of the revised comparative model, it was found that at least 70 per cent fell in the expected level in terms of the opposing theoretical system of cognitive development, thus it is possible to predict Piagetian performance from knowledge of Vygotsky performance (or vice versa) with a considerable degree of accuracy.

H_2 was also confirmed for all developmental stages and most individual tasks. Only the "Number of Hypotheses Mentioned" variable did not relate to age or cognitive sophistication in the Vygotsky investigation. As well, the initial judgement criteria for the Piagetian Density task displayed a very erratic pattern, although there was a general trend for older subjects to perform better. The 9 year old sample often seemed to slightly outperform their 10 year old counterparts although the difference usually did not reach statistical significance and the 16 year olds were usually beaten by the 15 year olds on many individual problems. The 5 year olds performed surprisingly well in terms of several of the individual scoring variables for the Vygotsky blocks. These slight discrepancies between age groups are probably a function of the small number of subjects at each level, and thus of quite minor significance. Overall however, increased age yeilded improved performance in terms of most aspects of both

theoretical systems.

It was not really expected that H_3 would be proven for every contrast between adjacent age levels, but rather only for those ages considered as boundaries of the major developmental stages. In the case of the Piagetian data, all concrete conservation tasks showed the expected break between 6 and 7 years of age, which confirmed division of performance into pre-operational and operational types. Neither the Volume task nor the Formal Operations Question revealed significant differences between age levels, although the Density task illustrated the Pre-operational and Concrete Stages, as well as a distinction between the 10 and 11 year olds. This may by interpreted as dividing the Concrete and the Formal Operations Periods, in view of the fact that the judgement criteria places attainment of Conservation of Density at 11 years. All formal level tasks considered together place the division slightly later, (at 12 years) and also reflect the earlier two stages. On the basis of the judgement criteria alone, all stages are perfectly reflected with boundaries occurring at 7-8 years and 11-12 years respectively. Explanation criteria reveal a slightly finer distinction, as an additional significant difference occurs at 8 and 9 years. This suggests the older children of the concrete operational level have a more thorough understanding of the conservation phenomenon than those just entering the stage.

Therefore, the occurrence of significantly different performance between age levels solidly supports all aspects of Piaget's model of cognitive development. In the case of the Vygotsky variables, the rater's data also indicate definite stages of sophistication, but at age levels slightly different from those estimates obtained by calculating the percentage of subjects placed in a given stage by the raters. A significant contrast occurs between the performance of the 6 and 7 year olds, reflective of the distinction between the Phase of Syncretic Images and the Phase of Complexes. Although very few of the sample actually operated totally in terms of Vygotsky's first phase, all of those who did were below 7 years of age, so the occurrence of this division seems legitimate. At the other extreme however, no significant breaks occurred until 14 - 15 years of age. The raters actually placed most of the 12 and 13 year olds in the Phase of Complexes as well, however, it seems gains in sophistication are relatively gradual until the final stage of Genuine Concepts is reached. This finding does not actually violate Vygotsky's model too drastically, if at all, in view of the fact that he considers mature Genuine Concepts to stem from two independent roots, represented by late Phase 2 and early Phase 3. Thus, Vygotsky expects that children will operate in terms of rudimentary concepts while still using complexes a great deal, thus no sharp jump from one phase to the other

would be anticipated. When the adolescent does become capable of operating in terms of genuine concepts, his use of complexes and potential concepts drops off considerably, although these earlier forms do not entirely disappear.

The individual Vygotsky scoring variables generally reflect gradual increase throughout the age levels tested, and thus do not illustrate the theoretical stages of cognitive development, although they are somewhat related to the expected pattern. Any significant differences that do appear usually occur between the youngest age levels explored, or between the lowest and the highest mean scores, in the case of variables tested by analysis of variance. Perhaps young children perform the most erratically on the Blocks, with relative stability being attained at about 7-8 years and smoothly increasing from there. These distinctions may reflect the disorganization of the youthful approach to a complex task such as this. Only the "Level of Verbalization" and the "Number of Examiner Clues" (which were found to be the most valuable individual scores in the battery) provide patterns definitely suggestive of the rater's data. These variables also reflect the distinction between 6 and 7 years of age, which may be reflective of youthful disorganization and/or Phase 1 thought. Actually the two terms are virtually interchangable, as syncretic images are described as "disorganized congeries" by Vygotsky (1962, p. 59). Thus at least some of the Vygotsky scoring

variables (Verbalization, Number of Examiner Clues, Time and Errors in the Final Regrouping) are indicative of the distinction between Phase 1 and Phase 2, even though it is probable that only the tail end of Phase 2 is actually included in the present study. This finding emphasizes the importance of Phase 1 to Vygotsky's conceptual model. Possibly, if a total score could be derived, the discrepancy between the two upper phases (or more likely between the final stage of genuine concepts and the earlier types of thought) would also emerge.

H_4 was unreservedly accepted, as no differences were found between male and female performance for any variable in either aspect of the present study. This finding confirms those of the vast majority of other investigators.

H_5 was rejected, as Conservation of Area was the most easily passed, followed by the Quantity Conservations, Substance, Weight, Area, Density and Volume. Other conclusions derived from these findings are discussed earlier in this chapter, under "Conclusions Drawn from the Piagetian Investigation"

All sections of H_6 were confirmed except part H, as older subjects did not necessarily offer a greater number of hypotheses for their various groupings of the blocks. Very young children often supplied very few hypotheses for their groupings, and slightly older subjects offered a great many low level reasons, whereas the oldest subjects often needed

only very few trial groups before the task was solved. Thus, this function approximated an inverted U shape, with the highest number of hypotheses occurring at about 9 years of age. Other scoring variables were found to operate as expected; as older subjects did verbalize the principle involved more effectively, used more mature types of concepts in their groupings, needed less time to reach the correct solution, required fewer clues, and formed the final grouping faster and more accurately. There was a general trend for older subjects to form their initial grouping faster, but this measure showed considerable variability, as some subjects of all age levels tended to contemplate the situation at some length before actually moving the blocks around. This seems to be more a function of personality than age, and has been noted by other investigators using the Vygotsky instrument (Hanfmann and Kasanin, 1942).

Implications for further research

The high rate of acceptance of the hypotheses investigated by this study indicates most of the obtained results were as anticipated, however a number of unexpected findings did emerge both from this investigation and from the review of other related work. All of the areas mentioned below would appear to be lucrative topics for further in depth study.

(1) The effect of neurological impairment on the various

References

Achenbach, T. M. Conservation of illusion-distorted identity: Its relation to MA and CA in normals and retardates. Child Development, 1969, 40, 663-679.

Achenbach, T. M. Conservation below age three: Fact or artifact? Proceedings of the 77th Annual Convention of the American Psychological Association, 1969, 4, 275-276.

Acker, N. Conservation and coordination of relations in Piaget's liquid quantity problem. Predoctoral thesis, University of Minnesota, 1968.

Aldrich, C. K. The relationship of the Concept Formation Test to drug addiction and to intelligence. Journal of Nervous and Mental Disease, 1944, 100, 30-34.

Almy, M., Chittenden, E., & Miller, P. Young children's thinking: Studies of some aspects of Piaget's theory. New York: Teachers College Press, 1966.

Anthony, J. Symposium on the contribution of current theories to understanding of child development. British Journal of Medical Psychology, 1957, 30, 255-269.

Ausubel, D. P. The transition from concrete to abstract cognitive functioning: Theoretical issues and implications for education. Journal of Research in Science Teaching, 1964, 2, 261-266.

Baggaley, A. R. Intermediate correlational methods. New York: Wiley & Sons, 1964.

References

Achenbach, T. M. Conservation of illusion-distorted identity: Its relation to MA and CA in normals and retardates. Child Development, 1969, 40, 663-679.

Achenbach, T. M. Conservation below age three: Fact or artifact? Proceedings of the 77th Annual Convention of the American Psychological Association, 1969, 4, 275-276.

Acker, N. Conservation and coordination of relations in Piaget's liquid quantity problem. Predoctoral thesis, University of Minnesota, 1968.

Aldrich, C. K. The relationship of the Concept Formation Test to drug addiction and to intelligence. Journal of Nervous and Mental Disease, 1944, 100, 30-34.

Almy, M., Chittenden, E., & Miller, P. Young children's thinking: Studies of some aspects of Piaget's theory. New York: Teachers College Press, 1966.

Anthony, J. Symposium on the contribution of current theories to understanding of child development. British Journal of Medical Psychology, 1957, 30, 255-269.

Ausubel, D. P. The transition from concrete to abstract cognitive functioning: Theoretical issues and implications for education. Journal of Research in Science Teaching, 1964, 2, 261-266.

Baggaley, A. R. Intermediate correlational methods. New York: Wiley & Sons, 1964.

Baker, N. E., & Sullivan, E. V. The influence of some task variables and of socio-economic class on the manifestation of conservation of number. Journal of Genetic Psychology, 1970, 116, 21-30.

Baldwin, A. L. Theories of child development. New York: Wiley & Sons, 1968.

Ball, T., & Campbell, M. L. Effect of Montessori's Cylinder Block Training on the acquisition of conservation. Developmental Psychology, 1970, 2, 156.

Barten, S. S., & Blank, M. Soviet research on speech and language: An American perspective. Early Child Development and Care, 1971, 1, 3-14.

Batt-Haee, M. A. Conservation of mass, weight and volume in an intermediate grade. Psychological Reports, 1971, 28, 163-168.

Beard, R. M. The nature and development of concepts, Part II. Educational Review, 1960, 13, 12-26.

Bearison, D. J. Role of measurement operations in the acquisition of conservation. Developmental Psycholcgy, 1969, 1, 653-660.

Begelman, D. A., & Steinfeld, G. J. Is there an error of the standard? A critique of Piaget's perceptual thecry. Journal of Genetic Psychclcgy, 1972, 86, 81-117.

Beilin, H. Perceptual-cognitive conflict in the development of an invariant area concept. Journal of Experimental Child Psychology, 1964, 1, 208-226.

Beilin, H. Learning and operational convergence in logical thought development. Journal of Experimental Child Psychology, 1965, 2, 317-339.

Beilin, H. Feedback and infralogical stratagies in invariant area conceptualization. Journal of Experimental Child Psychology, 1966, 3, 267-278.

Beilin, H. Cognitive capacities of young children: A replication. Science, 1968, 162, 920-921.

Beilin, H., & Franklin, I. C. Logical operations in area and length measurement: Age and training effects. Child Development, 1962, 33, 607-618.

Beilin, H., Kagan, J., & Rabinowitz, R. Effects of verbal and perceptual training on water-level representation. Child Development, 1966, 37, 317-330.

Berlyne, D. E. Recent developments in Piaget's work. British Journal of Educational Psychology, 1957, 27, 1-12.

Berlyne, D. E. Structure and direction in thinking. New York: Wiley, 1965.

Berzonsky, M. D. Interdependence of Inhelder and Piaget's model of logical thinking. Developmental Psychology, 1971, 4, 469-476.

Bever, T. G., Mehler, J., & Epstein, J. What children do in spite of what they know. Science, 1968, 162, 921-924.

Boehm, L. Exploring children's thinking. Elementary School Journal, 1961, 61, 363-373.

Bolles, M. M., & Goldstein, K. A study of the impairment of abstract behavior in schizophrenic patients. Psychiatric Quarterly, 1938, 12, 42-65.

Bolles, M. M., Rosen, G. P., & Landis, C. Psychological performance tests as prognostic agents for the efficiency of insulin therapy in schizophrenia. Psychiatric Quarterly, 1938, 12, 733-737.

Braine, M. D. S. The ontogeny of certain logical operations: Piaget's formulation examined by non-verbal methods. Psychological Monographs, 1959, 73, (5, Whole no. 475).

Braine, M. D. S. Piaget on reasoning: A methodological critique and alternative proposals. In W. Kessen & C. Kuhlman (Eds.), Thought in the young child. Monographs of the Society for Research in Child Development, 1962, 27 (2, no. 83), 41-61.

Braine, M. D. S. Development of a grasp of transitivity of length: A reply to Smedslund. Child Development, 1964, 35, 799-810.

Braine, M. D. S., & Shanks, B. L. The conservation of a shape property and a proposal about the origins of conservations. Canadian Journal of Psychology, 1965, 19, 197-207.

Braine, M. D. S., & Shanks, B. L. The development of conservation of size. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 227-242.

Brainerd, C. J. Continuity and discontinuity hypothesis in studies of conservation. Developmental Psychology, 1970, 3, 225-228.

Brainerd, C. J. The development of the proportionality scheme in children and adolescents. Developmental Psychology, 1971, 5, 469-476.

Brainerd, C. J. Judgements and explanation as criteria for the presence of cognitive structures. Psychological Bulletin, 1973, 79, 172-179.

Brainerd, C. J., & Allen, T. W. Experimental inductions of the conservation of 'first order' quantitative invariants. Psychological Bulletin, 1971a, 75, 128-144.

Brainerd, C. J., & Allen, T. W. Training and generalization of density conservation: Effects of feedback and consecutive similar stimuli. Child Development, 1971b, 42, 693-704.

Brainerd, C. J., & Brainerd, S. H. Order of acquisition of number and quantity conservation. *Child Development*, 1972, *43*, 1401-1406.

Brearley, M., & Hitchfield, E. *A guide to reading Piaget*. New York: Schocken Books, 1967.

Bright, G. W. Conservation of volume: Testing as a means of instruction. *Journal of Psychology*, 1972, *82*, 329-347.

Brison, D. W. Acceleration of conservation of substance. *Journal of Genetic Psychology*, 1966, *109*, 311-322.

Brison, D. W. , & Sullivan, E. V. (Eds.), *Recent research on the acquisition of conservation of substance*. Educational Research Series, 2. Toronto: The Ontario Institute for Studies in Education, 1967.

Bruner, J. S. The course of cognitive development. *American Psychologist*, 1964, *19*, 1-16.

Bruner, J. S. The growth of mind. *American Psychologist*, 1965, *20*, 1007-1017.

Bruner, J. S., Olver, R. R., & Greenfield, P. M. *Studies in cognitive growth*. New York: Wiley & Sons, 1966.

Bruner, J. S. *Towards a theory of instruction*. Cambridge, Mass.: Harvard University Press, 1966.

Bryant, P. E. Two causes of failure in children to sort by two different dimensions on successive trials. *British Journal of Educational Psychology*, 1967, *37*, 320-328.

Bryant, P. E. The understanding of invariance by very young children. *Canadian Journal of Psychology*, 1972, *26*, 78-95.

Calhoun, L. G. Number conservation in very young children: The effect of age and mode of responding. Child Development, 1971, 42, 561-572.

Cameran, N. Schizaphrenic thinking in a problem-solving situation. Journal of Mental Science, 1939, 85, 1012-1035.

Carlson, J. S. Effects of instruction on the concept of conservation of substance. Science Education, 1967, 51, 138-145.

Carpenter, T. E. A pilot study for a qualitative investigation of Jean Piaget's original work on concept formation. Educational Review, 1955, 7, 142-149.

Cathcart, W. G. The relationship between primary students' rationalization of conservation and their mathematical achievement. Child Development, 1971, 42, 755-765.

Charlesworth, W. R. Development of assessment of cognitive structures. Journal of Research in Science Teaching, 1964, 2, 215-219.

Chard, R. D., & Schwartz, B. D. A new modified concept formation test. American Psychologist, 1947, 2, 247.

Cheng, T., & Lee, M. An investigation into the scope of the conception of number among 6 - 7 year old children. Psychological Abstracts, 1961, 35, no. 4710.

Cole, M. & Maltzman, I. (Eds.) A handbook of contemporary Soviet psychology. New York: Basic Books, 1969.

Collins, J. The psychological theory of Jean Piaget: Some philosophical remarks. Alberta Journal of Educational Research, 1967, 13, 231-238.

Coon, R. C., & Odom, R. D. Transitivity and length judgements as a function of age and social influence. Child Development, 1968, 39, 1133-1144.

Cote, A. D. J. Piaget's recent formulations on perception and intelligence. *Alberta Journal of Educational Research*, 1967, *13*, 173-179.

Cote, A. D. J. Flexibility and conservation acceleration. Unpublished doctoral dissertation, University of Alberta, 1968.

Curcio, F., Kattef, E., Levine, D., & Robbins, O. Compensation and susceptibility to conservation training. *Developmental Psychology*, 1972, *7*, 259-265.

Delacy, E. A. Some problems associated with a paper-and-pencil test of conservation of length. *Child Development*, 1967, *38*, 869-875.

Denney, N. W. A developmental study of free classification in children. *Child Development*, 1972, *43*, 221-232.

Des Lauriers, A., & Halpern, F. Psychological tests in childhood schizophrenia. *American Journal of Orthopsychiatry*, 1947, *17*, 57-67.

The developmental approach of Jean Piaget: Open discussion. *American Journal of Mental Deficiency*, 1966, *70*, 84-105.

Diethelm, O. Review of *Conceptual thinking in schizophrenia*. *Psychosomatic Medicine*, 1943, *5*, 202.

Dodwell, P. C. Children's understanding of number and related concepts. *Canadian Journal of Psychology*, 1960, *14*, 191-205.

Dodwell, P. C. Children's understanding of number concepts: Characteristics of an individual and of a group test. *Canadian Journal of Psychology*, 1961, *15*, 29-36.

Dodwell, P. C. Children's understanding of spatial concepts. *Canadian Journal of Psychology*, 1963a, *17*, 141-161.

Dodwell, P. C. Relations between the understanding of the logic of classes and of cardinal numbers in children. Canadian Journal of Psychology, 1963b, 16, 152-160.

Duckworth, E. Piaget rediscovered. Journal of Research in Science Teaching, 1964, 2, 172-175.

Eifermann, R. R., & Etzion, D. Awareness of reversibility: Its effect on performance of converse arithmetical operations. British Journal of Psychology, 1964, 34, 151-157.

Elkind, D. Children's discovery of the conservation of mass, weight and volume: Piaget replication study II. Journal of Genetic Psychology, 1961a, 98, 219-227.

Elkind, D. Piagetian and psychometric conceptions of intelligence. Harvard Educational Review, 1969, 39, 319-337.

Elkind, D., & Flavell, J. H. (Eds.) Studies in cognitive development: Essays in honor of Jean Piaget. Toronto: Oxford University Press, 1969.

Elkind, D., & Schoenfeld, E. Identity and equivalence conservation at two age levels. Developmental Psychology, 1972, 6, 529-533.

Elkind, D., & Scott, L. Studies in perceptual development: I. The decentering of perception. Child Development, 1962, 33, 619-630.

Ervin, S. M. Training and a logical operation by children. Child Development, 1960, 31, 555-563.

Elkind, D. The development of the additive composition of classes in the child: Piaget replication study III. Journal of Genetic Psychology, 1961b, 99, 51-57.

Elkind, D. The development of quantitative thinking: A systematic replication of Piaget's studies. Journal of Genetic Psychology, 1961c, 98, 37-46.

Elkind, D. Quantity conceptions in junior and senior high school students. Child Development, 1961a, 32, 551-560.

Elkind, D. Discrimination, seriation and numeration of size and dimensional differences in young children: Piaget replication study VI. Journal of Genetic Psychology, 1964, 104, 275-296.

Elkind, D. Piaget's conservation problems. Child Development, 1967, 38, 15-27.

Estes, B. W. Some mathematical and logical concepts in children. Journal of Genetic Psychology, 1956, 88, 219-222.

Ezell, M., Hammerman, A., & Morse, S. A reply to K. Feigenbaum of January 1969. Young Children, 1969, 24, 310-312.

Farnham-Diggory, S., & Bermon, M. Verbal compensation, cognitive synthesis, and conservation. Merrill-Palmer Quarterly of Behavior and Development, 1968, 14, 215-227.

Feigenbaum, K. D. Task complexity and IQ as variables in Piaget's problem of conservation. Child Development, 1963, 34, 423-432.

Feigenbaum, K. D. Activities to teach the concept of conservation. Young Children, 1969, 24, 151-153.

Feigenbaum, K. D., & Sulkin, H. Piaget's problem of conservation of discontinuous quantities: A teaching experience. Journal of Genetic Psychology, 1964, 105, 91-97.

Ferguson, G. A. *Statistical analysis in psychology and education*. New York:McGraw-Hill, 1966.

Figurelli, J. C., & Keller, H. R. The effects of training and socio-economic class upon the acquisition of conservation concepts. *Child Development*, 1972, *43*, 293-298.

Fisher, S. Patterns of personality rigidity and some of their determinants. *Psychological Monographs*, 1950, *64* (1, Whole no. 307).

Flavell, J. H. *The developmental psychology of Jean Piaget*. Princeton: D. Van Nostrand, 1963.

Flavell, J. H. Stage-related properties of cognitive development. *Cognitive Psychology*, 1971, *2*, 421-451.

Fleck, J. R. Cognitive styles in children and performance on Piagetian conservation tasks. *Perceptual and Motor Skills*, 1972, *35*, 747-756.

Fleischmann, B., Gilmore, S., & Ginsburg, H. The strength of non-conservation. *Journal of Experimental Child Psychology*, 1966, *4*, 353-368.

Fodor, J. Some reflections on L. S. Vygotsky's . Language ') *Cognition* 1972, *1*, 83-95.

Fosberg, I. A. Multiple solutions to the Vygotsky Test. *American Psychologist*, 1946, *1*, 280.

Fosberg, I. A. A modification of the Vygotsky Block Test for the study of higher thought processes. *American Journal of Psychology*, 1947, *61*, 558-561.

Fraisse, P. (Ed.) *Traite de psychologie experimentale sans la direction de Paul Fraisse et Jean Piaget*. Paris: Presse Universitaire de France, 1963.

Frank, F. Perception and language in conversation. In J. S. Bruner, R. R. Olver, & P. M. Greenfield, _Studies in cognitive growth_. New York: Wiley & Sons, 1966.

French, T. M. Review of _Conceptual Thinking in Schizophrenia_. _Psychoanalytic Quarterly_, 1943, _12_, 257-259.

Freyberg, P. S. Concept development in Piagetian terms in relation to school attainment. _Journal of Educational Psychology_, 1966, _57_, 164-168.

Furth, H. G. Conservation of weight in deaf and hearing children. _Child Development_, 1964, _35_, 143-150.

Furth, H. G. _Piaget and knowledge_. Englewood Cliffs, New Jersey: Prentice-Hall, 1969.

Furth, H. G. Linguistic deficiency and thinking: Research with deaf subjects 1964-1969. _Psychological Bulletin_, 1971, _76_, 58-72.

Gaudia, G. Race, social class and age of achievement of conservation on Piagetian tasks. _Developmental Psychology_, 1972, _6_, 158-165.

Gelman, R. Conservation acquisition: A problem of learning to attend to relevant attributes. _Journal of Experimental Child Psychology_, 1969, _7_, 167-187.

Gelman, R., & Weinberg, D. H. The relationship between liquid conservation and compensation. _Child Development_, 1972, _43_, 371-383.

Gillespie, W. H. Review of _Conceptual Thinking in Schizophrenia_. _International Journal of Psychoanalysis_, 1942, _23_, 183.

Glick, J., & Wapner, S. Development of transitivity: Some findings and problems of analysis. _Child Development_, 1968, _39_, 621-638.

Goldschmid, M. L. Different types of conservation and non-conservation and their relation to age, sex, I.Q., M.A., and vocabulary. Child Development, 1967, 38, 1229-1246.

Goldschmid, M. L. The relation of conservation to emotional and environmental aspects of development. Child Development, 1968, 39, 579-589.

Goldschmid, M. L. The role of experience in the acquisition of conservation. In I. J. Athey & D. O. Rubadeau (Eds.), Educational implications of Piaget's theory. Waltham, Mass.: Ginn-Blaisdell, 1970, Pp. 114-118.

Goldschmid, M. L., & Bentler, P. M. The dimensions and measurement of conservation. Child Development, 1968, 39, 787-802.

Goodnow, J. J. A test of milieu effects with some of Piaget's tasks. Psychological Monograph, 1962, 76, (no. 36, Whole no. 555).

Goodnow, J., & Bethan, G. Piaget's tasks: The effect of schooling and intelligence. Child Development, 1966, 37, 573-582.

Green, R. T., & Laxon, V. J. The conservation of number, mother, water and a fried egg chez l'enfant. Acta Psychologica, 1970, 32, 1-30.

Griffiths, J. A., Shantz, C. A., & Sigel, I. E. A methodological problem in conservation studies: The use of relational terms. Child Development, 1967, 38, 841-848.

Gruen, G. E. Experiences affecting the development of number conservation in children. Child Development, 1965, 36, 964-979.

Gruen, G. E. Note on conservation: Methodological and definitional considerations. Child Development, 1966, 37, 977-983.

Gruen, G. E., & Vore, D. A. Development of conservation in normal and and retarded children. . 1972, _6_, 146-157.

Guilford, J. P. _Fundamental statistics in psychology and education_. New York:McGraw-Hill, 1965.

Gulutsan, M. Jean Piaget in Soviet psychology. _Alberta Journal of Educational Research_, 1967, _13_, 239-248.

Halasa, O. A developmental study of the attainment of number conservation among economically and culturally disadvantaged children. _Dissertation Abstracts_, 1967, _28_ (5-B), 2606-2607.

Halford, G. S. An experimental test of Piaget's notions concerning the conservation of quantity in children. _Journal of Experimental Child Psychology_, 1968, _6_, 33-43.

Halford, G. S. An experimental analysis of the criteria used by children to judge quantities. _Journal of Experimental Child Psychology_, 1969, _8_, 314-327.

Halford, G. S. A classification learning set which is a possible model for conservation of quantity. _Australian Journal of Psychology_, 1970a, _22_, 11-19.

Halford, G. S. A theory of the acquisition of conservation. _Psychological Review_, 1970b, _77_, 302-316.

Halford, G. S. Acquisition of conservation through learning a consistent classificatory system for quantities. _Australian Journal of Psychology_, 1971, _23_, 151-161.

Halford, G. S., & Fullerton, T. J. A discrimination task which induces conservation of number. _Child Development_, 1970, _41_, 205-213.

Hall, E. A conversation with Jean Piaget and Barbel Inhelder. _Psychology Today_, 1970, _3_, 25-56.

Hall, V. C., & Kingsley, R. Conservation and equilibration theory. Journal of Genetic Psychology, 1968, 113, 195-213.

Hall, V. C., Salvi, R., Seggev, L., & Caldwell, E. Cognitive synthesis, conservation, and task analysis. Developmental Psychology, 1970, 2, 423-428.

Halpern, E. The effects of incompatability between perception and logic in Piaget's stage of concrete operations. Child Development, 1965, 36, 491-498.

Hamel, B. R., Van der Veer, M. A. A., & Westerhoff, R. Identity, language activation training and conservation. British Journal of Educational Psychology, 1972, 42, 186-191.

Hanfmann, E. Analysis of the thinking disorder in a case of schizophrenia. Archives of Neurology and Psychiatry, 1939, 41, 568-579.

Hanfmann, E. Personal patterns in the process of concept formation. Psychological Bulletin, 1940, 37, 515-517.

Hanfmann, E. A study of personal patterns in an intellectual performance. Character and Personality , 1941, 9, 315-325.

Hanfmann, E. Concept Formation Test. In A. Weider (Ed.), Contributions toward medical psychology: Theory and psychodiagnostic methods , Vol. II.. New York: Ronald Press, 1953. Pp. 731-740.

Hanfmann, E., & Kasanin, J. A method for the study of concept formation. Journal of Psychology, 1937, 3, 521-540.

Hanfmann, E., & Kasanin, J. Conceptual thinking in schizophrenia. Nervous and Mental Disease Monographs, 1942, No. 67.

Harasym, C. R., Boersma, F. J., & Maguire, T. O. Semantic differential analysis of relational terms used in conservation. Child Development, 1971, 42, 767-779.

Hardeman, M. Children's moral reasoning. Journal of Genetic Psychology, 1972, 120, 49-59.

Hartmann, G. W. Review of Conceptual thinking in schizophrenia. American Journal of Psychology, 1947, 60, 146-148.

Hood, H. B. An experimental study of Piaget's theory of the development of number in children. British Journal of Psychology, 1962, 53, 273-286.

Hooper, F. H. Piaget's conservation tasks: The logical and developmental priority of identity conservation. Journal of Experimental Child Psychology, 1969, 8, 234-249.

Hunt, J. McV. Intelligence and experience. New York: Ronald Press, 1961.

Hyde, D. M. An investigation of Piaget's theories of the development of the concept of number. Unpublished doctoral dissertation, The University of London, 1959.

Hyde, D. M. Piaget and conceptual development, with a cross-cultural study of number and quantity. Toronto: Holt, Rinehart & Winston, 1970.

Inhelder, B. Criteria of the stages of mental development. In J. M. Tanner & B. Inhelder (Eds.), Discussions on child development. New York: International Universities Press, 1960.

Inhelder, B. Some aspects of Piaget's genetic approach to cognition. In W. Kessen & C. Kuhlman (Eds.), Thought in the young child, Monographs of the Society for Research in Child Development, 1962, 27 (2, No. 83). Pp. 19-34.

Inhelder, B. Operational thought and symbolic imagery. In P. H. Mussen (Ed.), European research in cognitive development, Monographs of the Society for Research in Child Development, 1965, 30, 4-18.

Inhelder, B. The diagnosis of reasoning in the mentally retarded, New York: John Day, 1968.

Inhelder, B., Bovet, M., Sinclair, H., & Smock, C. D. On cognitive development. American Psychologist, 1966, 21, 160-165.

Inhelder, B., & Piaget, J. The growth of logical thinking from childhood to adolescence: An essay on the construction of formal operational structures. New York: Basic Books, 1958. (Original French edition, 1955.)

Inhelder, B., & Piaget, J. The early growth of logic in the child: Classification and seriation. New York: Harper & Row, 1964. (Original French edition, 1959.)

Isaacs, N. New light on children's ideas of number: The work of Professor Piaget. London: Education Supply Association, 1960.

Isaacs, S. Intellectual growth in young children. New York: Harcourt, Brace & World, 1930.

Jones, P. A. Formal operational reasoning and the use of tentative statements. Cognitive Psychology, 1972, 3, 467-471.

Kasanin, J. The disturbances of conceptual thinking in schizophrenia. In J. Kasanin (Ed.), Language and thought in schizophrenia. Berkeley, Calif.: University of California Press, 1944. Pp. 41-49.

Kasanin, J., & Hanfmann, E. An experimental study of concept formation in schizophrenia: I. Quantitative analysis of results. American Journal of Psychiatry, 1938, 95, 35-52.

Kasanin, J., & Hanfmann, E. Disturbances in concept formation in schizophrenia. Archives of Neurology and Psychiatry, 1938, 40, 1276-1282.

Kaufman, A. S. Piaget and Gesell: A psychometric analysis of tests built from their tasks. Child Development, 1971, 42, 1341-1360.

Keasey, C. T., & Charles, D. C. Conservation of substance in normal and mentally retarded children. Journal of Genetic Psychology, 1967, 3, 271-279.

Kessen, W., & Kuhlman, C. (Eds.) Thought in the young child: Report of a conference on intellective development with particular attention to the work on Jean Piaget. Monographs of the Society for Research in Child Development, 1962, 2 (2, Serial No. 83).

King, W. L. A nonarbitrary behavioral criterion for conservation of illusion-distorted length in five-year-olds. Journal of Experimental Child Psychology, 1971, 2, 171-181.

Kingsley, R. C., & Hall, V. C. Training conservation through the use of learning sets. Child Development, 1967, 38, 1111-1126.

Klahr, D., & Wallace, J. G. An information processing analysis of some Piagetian experimental tasks. Cognitive Psychology, 1970, 1, 358-387.

Kofsky, E. A scalogram study of classificatory development. Child Development, 1966, 37, 191-204.

Kogan, K. L., & Kogan, W. S. Review of the Concept Formation Test. In O. K. Buros (Ed.), Fourth mental measurements yearbook. New Jersey: The Gryphon Press, 1953. P. 37.

Kohlberg, L., Yaeger, J., & Hjertholm, E. Private speech: Four studies and a review of theories. Child Development, 1968, 39, 691-736.

Kohnstamm, G. A. An evaluation of part of Piaget's theory. Acta Psycholcgica, 1963, 1, 313-356.

L'Abate, L. Consensus of choice among children: A test of Piaget's thecry of cognitive development. Journal of Genetic Psychology, 1962, 100, 143-149.

Larsen, G. Y., & Flavell, J. H. Verbal factors in compensation performance and the relation between conservation and compensation. Child Development, 1970, 41, 965-977.

Laurendeau, M., & Pinard, A. Causal thinking in the child: A genetic and experimental approach. New York: International Universities Press, 1962.

Lefrancois, G. R. Acquisition cf concepts of conservation. Unpublished doctoral dissertation, University of Alberta, 1966.

Lefrancois, G. R. Jean Piaget's developmental model: Equilibration-through-adaptation. Alberta Journal of Educational Research, 1967, 13, 161-172.

Lefrancois, G. R. A treatment hierarchy for the acceleration of conservation of substance. Canadian Journal of Psychology, 1968, 22, 277-284.

Leontiev, A. S., & Luria, A. R. The psychological ideas of L. S. Vygotskii. In B. B. Wolman (Ed.), Historical roots of contemporary psychology. New York: Harper & Row, 1968. Pp. 338-367.

Lister, C. M. The development of a concept of weight conservation in E. S. N. children. British Journal of Educational Psychology, 1969, 39, 245-252.

Lister, C. M. The development of a concept of volume conservation in E. S. N. children. British Journal of Educational Psychology, 1970, 40, 55-64.

Little, A. A longitudinal study of cognitive development in young children. Child Development, 1972, 43, 1024-1034.

Lloyd, B. B. Studies of conservation with Yoruba children of differing ages and experience. Child Development, 1971, 42, 415-428.

Long, L., & Welch, L. The development of the ability to discriminate and match numbers. Journal of Genetic Psychology, 1941, 59, 377-387.

Lovell, K. A follow-up study of some aspects of the work of Piaget and Inhelder on the child's conception of space. British Journal of Educational Psychology, 1959, 29, 104-117.

Lovell, K., & Ogilvie, E. A study of the concept of conservation of substance in the junior school child. British Journal of Educational Psychology, 1960, 30, 109-118.

Lovell, K. A follow-up study of Inhelder and Piaget's The growth of logical thinking. ()u British Journal of Educational Psychology, 1961a, 52, 143-153.

Lovell, K., & Ogilvie, E. The growth of the concept of volume in junior school children. Journal of Child Psychology and Psychiatry, 1961b, 2, 118-126.

Lovell, K. Growth of basic mathematical and scientific concepts in children. New York: Philosophical Library, 1965.

Lovell, K. Remarks in discussion. American Journal of Mental Deficiency, 1966, 70, 84-105.

Lovell, K., Healey, D., & Rowland, A. D. Growth of some geometrical concepts. Child Development, 1962, 33, 751.

Lovell, K., Mitchell, B., & Everett, I. R. An experimental study of the growth of some logical structure. British Journal of Psychology, 1962, 53, 175-188.

Lovell, K., & Ogilvie, E. A study of the conservation of weight in the junior school child. British Journal of Educational Psychology, 1961a, 31, 138-144.

Lovibond, S. H. The Object Sorting Test and conceptual thinking in schizophrenia. Australian Journal of Psychology, 1954, 6, 52-70.

Lumsden, E. A., & Kling, K. J. The relevance of an adequate concept of 'bigger' for investigations of size conservation: A methodological critique. Journal of Experimental Child Psychology, 1969, 8, 82-91.

Lunzer, E. A. Some points of Piagetian theory in the light of experimental criticism. Journal of Child Psychology and Psychiatry, 1960, 1, 191-202.

Maskin, M. Review of Conceptual thinking in schizophrenia. Psychiatry, 1943, 6, 248-249.

McManis, D. L. Conservation and transitivity of weight and length by normals and retardates. Developmental Psychology, 1969a, 4, 373-382.

McManis, D. L. Conservation of identity and equivalence of quantity by retardates. Journal of Genetic Psychology, 1969b, 115, 63-69.

Meece, R. S., & Rosenblum, S. Conceptual thinking of sixth-grade children as measured by the Vigotsky Block Test. Psychological Reports, 1965, 17, 195-202.

Mehler, J., & Bever, T. G. Cognitive capacity of very young children. Science, 1967, 158, 141-142.

Mehler, J., & Bever, T. G. Reply by J. Mehler and T. G. Bever. _Science_, 1968, _162_, 979-981.

Mermelstein, E. A note on Piaget's clinical method of questioning. _Alberta Journal of Educational Research_, 1967, _13_, 181-184.

Mermelstein, E., Carr, E., Mills, D., & Schwartz, J. Training techniques for the concept of conservation. _Alberta Journal of Educational Research_, 1967, _13_, 185-200.

Mermelstein, E., & Meyer, E. Conservation training techniques and their effects on different populations. _Child Development_, 1969, _40_, 471-490.

Mermelstein, E., & Shulman, L. S. Lack of formal schooling and the acquisition of conservation. _Child Development_, 1967, _38_, 39-52.

Miller, E. O. New use for the Vigotsky Blocks. _Journal of Clinical Psychology_, 1965, _11_, 87-89.

Miller, P. H. Attention to stimulus dimensions in the conservation of liquid quantity. _Child Development_, 1973, _44_, 129-136.

Mink, O. G. Experience and cognitive structure. _Journal of Research in Science Teaching_, 1964, _2_, 196-203.

Moynahan, E., & Glick, J. Relation between identity and equivalence conservation within four conceptual domains. _Developmental Psychology_, 1972, _6_, 247-251.

Muncie, W. Review of _Conceptual thinking in schizophrenia_. _Mental Hygiene_, 1943, _27_, 318-320.

Murray, F. B. Conservation of illusion-distorted lengths and areas by primary school children. _Journal of Educational Psychology_, 1965, _56_, 62-66.

Murray, F. B. Conseration of illusion-distorated length and illusion strength. Psychcnomic Science, 1967, 7, 65-66.

Murray, F. B. Cognitive conflict and reversibility training in the acquisition of length conservation. Journal of Educational Psychology, 1968a, 49, 82-87.

Murray, F. B. Phenomenal-real discrimination and the conservaticn of illusicn-distorted length. Canadian Journal of Psychology, 1968b, 22, 114-121.

Murray, F. B. Verbal and non-verbal assessment of the conservation of illusion-distorted lengths. Journal for Research in Mathematics Education, 1970a, 1, 9-6.

Murray, F. B. Stimulus mode and the conservaticn of weight and number. Journal of Educational Psychology, 1970b, 61, 287-291.

Murray, F. B. Acquisition of conservation through social interaction. Develcpmental Psychology, 1972, 6, 1-6.

Murray, J. P., & Youniss, J. Achievement of inferential transitivity and its relaticn to serial ordering. Child Develcpment, 1968, 39, 1259-1268.

Mussen, P. H. (Ed.) European research in cognitive development. Moncgraphs of the Society for Research in Child Develorment, 1965, 30, (No. 2).

Norman, R. D., Baker, C. A., & Doehring, D. G. The Hanfmann-Kasanin Concept Fcrmation Test as a measure of rigidity in relation to college aptitude and achievement. Journal of Clinical Psychology, 1950, 6, 365-369.

Northman, J. E., & Gruen, G. E. Relationship between identity and equivalence conservation. Developmental Psychology, 1970, 2, 311.

Overbeck, C., & Schwartz, M. Training in conservation of weight. Journal of Experimental Child Psychology, 1970, 9, 253-264.

O'Bryan, K. G., & Boersma, F. J. Eye movements, perceptual activity and conservation development. Journal of Experimental Child Psychology, 1971, 12, 157-169.

O'Bryan , K. G., & MacArthur, R. S. A factor analytic study of Piagetian reversibility. Alberta Journal of Educational Research, 1967, 13, 211-220.

O'Bryan, K. G., & MacArthur, R. S. Reversibility, intelligence and creativity in nine year old boys. Child Development, 1969, 40, 33-45.

Ojemann, R. H., & Pritchett, K. Piaget and the role of guided experiences in development. Perception and Motor Skills , 1963, 17, 927-940.

Overholt, E. D. A Piagetian conservation concept. Arithmetic Teacher, 1965, 12, 317-326.

Pace, A. The effect of instruction upon the development of the concept of number. Journal of Educational Research, 1968, 62, 183-189.

Palmer, E. L. The equilibration process: Some implications for instructional research and practice. In I. Athey & D. O. Rubadeau (Eds.), Educational Implications of Piaget's Theory. Walthom, Mass.:Ginn-Blaisdell, 1970, 18-26.

Papalia, D. E. The status of several conservation abilities across the life span. Human Development, 1972, 15, 231-241.

Papalia, D. E., & Hooper, F. H. A developmental comparison of identity and equivalence conservations. Journal of Experimental Child Psychology, 1971, 12, 347-361.

Peel, E. A. Experimental examination of some of Piaget's schemata concerning children's perceptions and thinking and a discussion of their educational significance. British Journal of Educational Psychology, 1959, 29, 89-103.

Peisach, E., & Wein, N. Relationship of conservation explanations to item difficulty. Journal of Genetic Psychology, 1970, 117, 167-180.

Penny, R. The Vigotsky Block Test: A form of administration. Australian Journal of Psychology, 1951, 3, 65-83.

Peters, D. L. Verbal mediators and cue discrimination in the transition from nonconservation to conservation of number. Child Development, 1970, 41, 707-721.

Peters, D. L., & Rubin, K. The effects of cued materials and transformation variations on conservation of number performance. Alberta Journal of Educational Research, 1969, 15, 47-56.

Pettigrew, T. F. The measurements and correlates of category width as a cognitive variable. Journal of Personality, 1958, 26, 532-544.

Phillips, D. G. The development of the concept of displacement volume: A hierarchical model and its partial testing under two methods of presentation. Journal of Research in Science Teaching, 1971, 8, 9-19.

Phillips, J. L. The orgin of intellect: Piaget's theory. San Francisco: W. H. Freeman, 1969.

Piaget, J. Judgment and reasoning in the child. New York: Harcourt, Brace & World, 1928. Original French edition, 1924.

Piaget, J. Les nations de mouvement et de vitesse chez l'enfant. Paris: Presses Universitaures, 1946.

Piaget, J. _The psychology of intelligence_. London: Routledge & Kegan Paul, 1950. (Original French edition, 1947.)

Piaget, J. How children form mathematical concepts. _Scientific American_, 1953b, _189_, 74-79.

Piaget, J. _Logic and psychology_, Original French edition, 1953. New York: Basic Books, 1957.

Piaget, J. The genetic approach to the psychology of thought. _Journal of Educational Psychology_, 1961, _52_, 275-281.

Piaget, J. _Comments on Vygotsky's critical remarks concerning "The language and thought of the child" and "Judgment and reasoning in the child"_. Cambridge, Mass.: MIT Press, 1962a.

Piaget, J. The stages of the intellectual development of the child. _Bulletin of the Menninger Clinic_, 1962b, _26_, 120-128.

Piaget, J. _The origins of intelligence in children_. New York: W. W. Norton, 1963. Original French edition, 1936.

Piaget, J. Development and learning. _Journal of Research in Science Teaching_, 1964, _2_, 176-186.

Piaget, J. _The child's conception of number_. New York: W. W. Norton, 1965. (Original French edition, 1941.)

Piaget, J. Response to Brian Sutton-Smith. _Psychological Review_, 1966, _73_, 111-112.

Piaget, J. _Six psychological studies_. New York: Random House, 1967a. Original French edition, 1964.

Piaget, J. Cognitions and conservations. Contemporary Psychclogy, 1967b, 12, 532-533.

Piaget, J. On the development of memory and identity, Barre. Mass.: Clark University Press, 1968a.

Piaget, J. Piaget's theory. In P. H. Mussen, (Ed.), Carmichael's Manual of child psychology, vol. 1. New York: Wiley & Son, 1968b, 162, Pp. 976-979.

Piaget, J. Genetic epistomclogy, New York: Columbia University Press, 1970.

Piaget, J. Psychology and epistomology, New York: Orian Press, 1971.

Piaget, J. Intellectual evclution from adolescence to adulthood. Human Development, 1972, 15, 1-12.

Piaget, J., & Fraisse, P. Experimental psychology: Its scope and method, New York: Basic Books, 1968.

Piaget, J., & Inhelder, B. Le developpement des quantities chez l'enfant. Delachauz et Niestle, neuchatel, 1941.

Piaget, J., & Inhelder, B. Diagnosis of mental operations and theory of intelligence. American Journal of Mental Deficiency, 1947, 51, 401-406.

Piaget, J., & Inhelder, B. The child's conception of space. London: Routledge & Kegan Paul, 1956. Original French edition, 1948.

Piaget, J., & Inhelder, B. Le develcppement des quantities physiques chez l'enfant: Conservation et alamisme. Neuchatel: Delachaux et Niestle, 1962.

Piaget, J., & Inhelder, B. The psychology of the child. New York: Basic Books, 1969.

Pickford, A. S., & Pickford, R. W. P. Review of _Conceptual Thinking in Schizophrenia_. _British Journal of Educational Psychology_, 1943, _33_, 187-188.

Pinard, A., & Laurendeau, M. A scale of mental development based on the theory of Piaget: Description of a project. _Journal of Research in Science Teaching_, 1964, _2_, 253-260.

Pollack, R. H. The developmental approach of Jean Piaget: Discussion. _American Journal of Mental Deficiency_, Monograph supplement, 1966, _70_, 79-83.

Pratoomraj, S., & Johnson, R. C. Kinds of questions and types of conservation tasks as related to children's conservation responses. _Child Development_, 1966, _37_, 343-353.

Price-Williams, D. R. Abstract and concrete modes of classification in a primitive society. _British Journal of Educational Psychology_, 1962, _32_, 50-61.

Price-Williams, D., Gordon, W., & Ramirez, M. Skill and conservation: A study of pottery-making children. _Developmental Psychology_, 1969, _1_, 769.

Pufall, P. B., Shaw, R. E., & Syrdalhasky, A. Development of number conservation: An examination of some predictions from Piaget's stage analysis and equilibration model. _Child Development_, 1973, _41_, 21-27.

Rappaport, D. Concept formation tests and personality research. _Psychological Bulletin_, 1941, _38_, 597-598.

Rappaport, D. Principles underlying projective techniques. _Character and Personality_, 1942, _10_, 213-219.

Rappaport, D., Gill, M. M. & Schafer, R. The Hanfmann-Kasanin Test. In _Manual of diagnostic psychological testing: I. Diagnostic testing and intelligence and concept formation_. New York: Josiah Macy Jr. Foundation, 1944. Pp. 209-213.

Rappaport, D., Gill, M. M. & Schafer, R. The Hanfmann-Kasanin Test. In *Diagnostic psychological testing: The theory, statistical evaluation and diagnostic application of a battery of tests*, Vol. I. Chicago: Year Book Publishers, 1945. Pp. 462-468.

Rappaport, D., Gill, M. M., & Schafer, R. *Diagnostic psychological testing*. (Robert R. Holt, Ed.) New York: International Universities Press, 1968.

Rawson, H. I. Piaget's conception of logical development and its relation to comprehension in reading. Unpublished master's thesis, University of Alberta, 1965.

Ripple, R. E., & Rockcastle, V. N. (Eds.) Piaget rediscovered: Selected papers from a conference on cognitive studies and curriculum development. *Journal of Research in Science Teaching*, 1964, *2*, 165-268.

Roll, S. Reversibility training and stimulus desirability as factors in conservation of number. *Child Development*, 1970, *41*, 501-507.

Rothenberg, B. B. Conservation of number among four- and five-year-old children: Some methodological considerations. *Child Development*, 1969, *40*, 383-406.

Rothenberg, B. B., & Courtney, R. G. Conservation of number in very young children: A replication of and comparison with Mehler and Bever's study. *Journal of Psychology*, 1968, *70*, 205-212.

Rothenberg, B. B., & Courtney, R. G. Conservation of number in very young children. *Developmental Psychology*, 1969, *1*, 493-502.

Rothenberg, B. B., & Orost, J. H. The training of conservation of number in young children. *Child Development*, 1969, *40*, 707-726.

Sawada, D., & Nelson, L. D. Conservation of length: Methodological considerations. Alberta Journal of Educational Research, 1968a, 14, 23-35.

Sawada, D., & Nelson, L. D. Transformations: Length conservation. Alberta Journal of Educational Research, 1968b, 14, 137-150.

Saltz, E., & Sigel, I. E. Concept over-discrimination in children. Journal of Experimental Psychology, 1967, 73, 1-8.

Schnall, M., Alter, E., Swanlund, T., & Schweitzer, T. A sensory-motor context affecting performance in a conservation task: A closer analog of reversibility than empirical return. Child Development, 1972, 43, 1012-1023.

Schwartz, M. M., & Scholnick, E. K. Scalogram analysis of logical and perceptual components of conservation of discontinuous quantity. Child Development, 1970, 41, 695-705.

Semeonoff, B., & Laird, A. J. The Vygotsky Test as a measure of intelligence. British Journal of Psychology, 1952, 43, 94-102.

Semeonoff, B., & Trist, E. Diagnostic performance tests. London: Tavistock Publications, 1958.

Shantz, C. V., & Smock, C. D. Development of distance conservation and the spatial co-ordinate system. Child Development, 1966, 37, 943-948.

Sigel, I. E. Developmental trends in the abstraction ability of children. Child Development, 1953, 24, 131-144.

Sigel, I. E. The attainment of concepts. In M. L. Hoffman & L. Hoffman (Eds.), Review of child development research, Vol. I. New York: Russell Sage Foundation, 1964. Pp. 209-248.

Sigel, I. E., & Hooper, F. H. (Eds.) Logical thinking in children: Research based cn Piaget's theory. New York: Holt, Rinehart & Winston, 1968.

Sigel, I. E., Roeper, A., & Hooper, F. H. A training procedure for acquisition of Piaget's conservation of quantity: A pilot study and its replication. British Journal of Educational Psychology, 1966, 36, 301-311.

Sigel, I. E., Saltz, E., & Roskind, W. Variables determining concept conservation. Journal of Experimental Psychology, 1967, 7, 471-475.

Siegel, S. Non-parametric statistics for the behavioral sciences. New York: McGraw-Hill, 1956.

Silvermann, L., & Schneider, D. S. A study of the development of conservation by a non-verbal method. Journal of Genetic Psychology, 1968, 112, 287-291.

Simpson, R. E. The effects of cognitive styles and age in achieving conservation concepts of substance, weight and volume. Dissertation Abstracts, 1970, 31, 3353A, No. 71-1273.

Smedslund, J. The acquisition of conservation of substance and weight in children: I. Introduction. Scandinavian Journal of Psychology, 1961a, 2, 11-20.

Smedslund, J. The acquisition of conservation of substance and weight in children: II. External reinforcement of conservation of weight and the operations of additions and subtraction. Scandinavian Journal of Psychology, 1961b, 2, 85-87.

Smedslund, J. The acquisition of conservation of substance and weight in children: III. Extinction of conservation of weight acquired normally and by means of empirical controls on a balance. Scandinavian Journal of Psychology, 1961c, 2, 85-87.

Smedslund, J. The acquisition of conservation of substance and weight in children: IV. Attempt at extinction of the visual components of the weight concept. Scandinavian Journal of Psychology, 1961d, 2, 153-155.

Smedslund, J. The acquisition of conservation of substance and weight in children: V. Practice in conflict situations without external reinforcement. Scandinavian Journal of Psychology, 1961e, 2, 156-160.

Smedslund, J. The acquisition of conservation of substance and weight in children: VI. Practice in continuous vs. discontinuous material in problem situations without external reinforcement. Scandinavian Journal of Psychology, 1961f, 2, 203-210.

Smedslund, J. The acquisition of conservation of substance and weight in children: VII. Conservation of discontinuous quantity and the operations of adding and taking away. Scandinavian Journal of Psychology, 1962, 3, 69-77.

Smedslund, J. Development of concrete transitivity of length in children. Child Development, 1963a, 34, 389-405.

Smedslund, J. The effect of observation on children's representation of the spatial orientation of a water surface. Journal of Genetic Psychology, 1963b, 102, 198-201.

Smedslund, J. Concrete reasoning: A study of intellectual development. Monographs of the Society for Research in Child Development, 1964a, 29 (2, No. 93.)

Smedslund, J. Internal necessity and contradiction in children's thinking. Journal of Research in Science Teaching, 1964b, 2, 220-221.

Smedslund, J. The development of transitivity of length: A comment on Braine's reply. Child Development, 1965, 36, 577-580.

Smedslund, J. Microanalysis of concrete reasoning: I. The difficulty of some combinations of addition and subtraction of one unit. _Scandinavian Journal of Psychology_, 1966a, _7_, 145-156.

Smedslund, J. Microanalysis of concrete reasoning: II. The effect of number and transformations and non-redundant elements, and of some variations in procedure. _Scandinavian Journal of Psychology_, 1966b, _7_, 157-163.

Smedslund, J. Microanalysis of concrete reasoning: III. Theoretical overview. _Scandinavian Journal of Psychology_, 1966c, _7_, 164-167.

Smith, I. D. The effects of training procedures upon the acquisition of conservation of weight. _Child Development_, 1968, _39_, 515-526.

Soenstroem, A. M. On the conservation of solids. In J. S. Bruner, R. R. Olver, & P. M. Greenfield, _Studies in cognitive growth_. New York: Wiley & Sons, 1966.

Staats, A. W., & Staats, C. K. _Complex human behavior: A systematic extension of learning principles_. New York: Holt, Rinehart & Winston, 1964.

Stewin, L. L. The nature of rigidity as determined by the Vygotsky Test. Unpublished master's thesis, University of Alberta, 1968.

Stones, E. Verbal labelling and concept formation in primary school children. _British Journal of Educational Psychology_, 1970, _40_, 245-252.

Stones, E., & Heslop, J. R. The formation and extension of class concepts in primary school children. _British Journal of Educational Psychology_, 1968, _38_, 261-271.

Sullivan, E. V. Transition problems in conservation research. _Journal of Genetic Psychology_, 1969, _115_, 41-54.

Szeminska, A. The evolution of thought: Some applications of research findings to educational practice. In P. H. Mussen, (Ed.), European research in cognitive development, Monographs of the Society for Research in Child Development, 1965, 30, (No. 2) Pp. 47-57.

Tanner, J. M., & Inhelder, B. (Eds.) Discussions on child development: A consideration of the biological, psychological and cultural approaches to the understanding of human development and behavior. New York: International Universities Press, 1960.

Thompson, C. Review of Conceptual Thinking in Schizophrenia. Psychoanalytic Review, 1946, 33, 382-384.

Thompson, J. The ability of children of different grade levels to generalize in sorting tests. Journal of Psychology, 1941, 11, 119-126.

Tisher, R. P. A Piagetian questionnaire applied to pupils in a secondary school. Child Development, 1971, 42, 1633-1636.

Tobin, M. J. Conservation of substance in the blind and the partially sighted. British Journal of Educational Psychology, 1972, 42, 192-197.

Torgerson, W. S. Theory and methods of scaling. New York: Wiley, 1958.

Towler, J. O. Training effects and concept development: A study of the conservation of continuous quantity in children. Unpublished doctoral dissertation, University of Alberta, 1967.

Towler, J. O., & Wheatley, G. Conservation concepts in college students. Journal of Genetic Psychology, 1971, 118, 265-270.

Travis, L. Conservation acceleration through successive approximations. Unpublished master's thesis, University of Alberta, 1969.

Tuddenham, R. D. Jean Piaget and the world of the child. American Psychologist, 1966, 21, 207-217.

Uzgiris, I. C. Situational generality of conservation. Child Development, 1964, 35, 831-841.

Veer, M. A. V. Zaporozhets: A Soviet developmental psychologist. Unpublished master's thesis, University of Alberta, 1967.

Vigotsky, L. S. The problem of the cultural development of the child. Journal of Genetic Psychology, 1929, 36, 415-434.

Vigotsky, L. S. Thought in schizophrenia. Archives of Neurological Psychiatry, 1934, 31, 1063-1077.

Vigotsky, L. S. Thought and language. Cambridge, Mass.: The M. I. T. Press, 1962.

Vigotsky, L. S. Development of the higher mental functions. In A. Leontyev, A. Luriya, & A. Smirnov (Eds.), Psychological research in the U.S.S.R., Vol. 1. Moscow: Progress Publishers, 1966. Pp. 11-46.

Vinacke, W. E. The investigation of concept formation. Psychological Bulletin, 1951, 48, 1-31.

Vygotsky Memorial Issue, Soviet Psychology, 1967, 5.

Vinh-Bang, J. Evaluation des conduites et apprentissage. In A. Morf, J. Smedslund, Vinn-Bang, & J. F. Wohlwill, L'appentissage des structures logiques. Etuder d' epistemalogie genetique, 1959, 3-13.

Wallace, J. G. Some issues raised by a non-verbal test of number concepts. Educaticnal Review, 1966, 18, 122-135.

Wallace, J. G. Concept growth and the education of the child: A survey of research in conceptualization. New York: New York University Press, 1967.

Wallace, J. G. An approach to the acceleration of number conservation in children. Educational Review, 1968, 20, 224-238.

Wallach, L., & Sprott, R. L. Inducing number conservation in children. Child Development, 1964, 35, 1057-1071.

Wallach, L., Wall, A. J., & Anderson, L. Number conservation: The roles of reversibility, addition-subtraction and misleading perceptual cues. Child Development, 1967, 38, 425-442.

Wallach, M. A. Research on children's thinking. In H. W. Stevenson (Ed.), Sixty-Second yearbook of the National Society for the Study of Education, Part I. Chicago,: National Society for the Study of Education, 1963, Pp. 236-276.

Wasik, B. H., & Wasik, J. I. Performance of culturally deprived children on the Concept Assessment Kit. Child Development, 1971, 42, 1586-1590.

Watson, J. S. Conservation: An S-R analysis. In I. E. Sigel & F. H. Hooper, (Eds.), Logical thinking in children: Research based on Piaget's theory., New York: Holt, Rinehart, and Winston, 1968, Pp. 447-460.

Wei, T. T. D., Lavatelli, C. B., & Jones, R. S. Piaget's concept of classification: A comparative study of socially disadvantaged and middle class children. Child Development, 1971, 42, 919-928.

Winer, B. J. Statistical principles in experimental design. New York:McGraw-Hill, 1962.

Winer, G. A. Induced set and acquisition of number conservation. Child Development, 1968, 39, 195-205.

Wohlwill, J. F. Developmental studies of perception. Psychological Bulletin, 1960a, 57, 249-288.

Wohlwill, J. F. A study of the development of the number concept by scalogram analysis. Journal of Genetic Psychology, 1960b, 97, 345-377.

Wohlwill, J. F. From perception to inference: A dimension of cognitive development. In W. Kessen & C. Kuhlman (Eds.), Thought in the young child. Monographs of the Society for Research in Child development, 1962, 27 (2, No. 83). Pp. 87-106.

Wohlwill, J. F. Piaget's system as a source of empirical research. Merrill-Palmer Quarterly, 1963, 9, 253-262.

Wohlwill, J. F. Cognitive development and the learning of elementary concepts. Journal of Research in Science Teaching, 1964, 2, 222-226.

Wohlwill, J. F. Comments in discussion on the developmental approach of Jean Piaget. American Journal of Mental Deficiency, Monograph supplement, 1966a, 70, 84-105.

Wohlwill, J. F. Piaget's theory of the development of intelligence in the concrete-operations period. American Journal of Mental Deficiency, Monograph supplement, 1966b, 70, 57-83.

Wohlwill, J. F. The mystery of the pre-logical child. Psychology Today, 1967, 1, 25-34.

Wohlwill, J. F., & Lowe, R. C. Experimental analysis of the development of the conservation of number. Child Development, 1962, 33, 153-168.

Wolinsky, G. F. Piaget's theory of perception: Insights for educational practices with children who have perceptual difficulties. Training School Bulletin, 1965, 62, 12-25.

Woodward, M. The behavior of idiots interpreted by Piaget's theory of sensory-motor development. British Journal of Educational Psychology, 1959, 29, 60-71.

Woodward, M. Concepts of number of the mentally subnormal studied by Piaget's method. Journal of Child Psychology and Psychiatry, 1961, 2, 249-259.

Wright, D. G. Review of Conceptual thinking in schizophrenia. American Journal of Psychiatry, 1943, 100, 299-300.

Zaporozhetz, A. V. L. S. Vygotsky's role in the study of problems of perception. Soviet Psychology, 1967, 5, 19-27.

Zangwill, O. L. Review of the Concept Formation Test. In O. K. Buros (Ed.), The third mental measurements yearbook. Highland Park, N.J.: The Gryphon Press, 1949.

Zimilies, H. A note on Piaget's concept of conservation. Child Development, 1963, 34, 691-695.

Zimilies, H. The development of conservation and differentiation of number. Monographs of the Society for Research in Child Development, 1966, 31, no. 6 (108).